Klohn Crippen Berger

Teck Highland Valley Copper Partnership

2018 Dam Safety Inspection Report

Highland Tailings Storage Facility

CANADA'S BEST MANAGED COMPANIES Platinum member

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March 29, 2018

Teck Highland Valley Copper Partnership
PO Box 1500
Logan Lake, British Columbia
V0K 1W0

Mr. Chris Anderson
Manager, Tailings and Water

Dear Mr. Anderson:

2018 Dam Safety Inspection
Highland Tailings Storage Facility

We are pleased to submit the 2018 Dam Safety Inspection report for the Highland Tailings Storage Facility, for THVCP review. The inspection and this report were prepared to comply with Section 10.5.3 of the Health, Safety and Reclamation Code for Mines in British Columbia (the Code), Section 4.2 “Annual Tailings Facility and Dam Safety Inspection Report” of the Code Guidance Document.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

Rick Friedel, P.Eng.
Engineer of Record, Approved Designate
Senior Geotechnical Engineer, Principal

RF/BC:cd

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2018 Dam Safety Inspection Report

Highland Tailings Storage Facility

EXECUTIVE SUMMARY

Klohn Crippen Berger Ltd. (KCB) were engaged by Teck Highland Valley Copper Partnership (THVCP) to complete the 2018 Dam Safety Inspection (DSI) of the Highland Tailings Storage Facility (TSF) on the Highland Valley Copper (HVC) mine site in accordance with requirement of the Health, Safety and Reclamation Code for Mines in British Columbia (the Code). The HVC site is located near Logan Lake, approximately 45 km south of Kamloops, in the interior of British Columbia.

The DSI includes the L-L Dam and H-H Dam, three seepage collection ponds at the toe of the L-L Dam (Seepage Pond 2, Seepage Water Reclaim Pond), two active slimes ponds at the toe of the L-L Dam (Slimes Pond 2 and Slimes Pond 4), and 24 Mile Lake downstream of H-H Dam. The visual inspection was completed by the Engineer of Record (EoR), Mr. Bill Chin, P.Eng. and Engineer of Record – Approved Designate[1] (EoR-AD), Mr. Rick Friedel P.Eng., P.E., both as representatives of KCB on September 11, 2018. Mr. Chris Anderson, P. Eng., THVCP Manager, Tailings and Water, is the TSF Qualified Person (as defined by the Code) for the Highland TSF.

The Highland TSF is located approximately 6.5 km northwest of the operating mill, refer to Figure 1. Tailings from ongoing mining operations are discharged into the Highland TSF. The tailings are retained by the H-H Dam (east end) and L-L Dam (west end) which are incrementally raised to meet tailings storage requirements, typically on an annual basis. The tailings beach slopes from the H-H Dam towards the L-L Dam which is ~9 km away. The tailings pond is in front of L-L Dam while no significant ponding occurs at the H-H Dam.

The pond volume and rate of pond rise was elevated during 2018 compared to recent years due to additional water stored in the impoundment from the Lornex Pit dewatering project which is now complete. The L-L Dam crest elevation was adequate to accommodate the increased rate of rise while maintaining adequate freeboard and flood storage. THVCP water balance forecasts a 1.9 m rise in 2019 (to El. 1252.8 m) which is more consistent with recent trends.

The H-H Dam is a pit waste dam with a glacial till core which extends vertically from the glacial till starter dam. The dam has been raised above the starter dam using the centreline method, similar to L-L Dam. Refer to Appendix III-B for select design drawings and typical cross sections. As of the end of 2018, the crest elevation of H-H Dam is sloped to match the tailings beach slope (El. 1273 m to 1280 m), corresponding to a maximum downstream slope height (crest to toe) of about 55 m. The currently permitted ultimate crest of the H-H Dam is El. 1292.7 m to El. 1298 m.

24 Mile Lake is an active containment facility which receives emergency discharge of water and tailings from the H-H Pumphouse during tailings line maintenance and operational upsets. The facility area was formally a natural lake that is now surrounded by waste dumps with no clearly defined dam structure. In 2017, KCB completed an assessment (KCB 2018b) which concluded there is no credible failure mode for the 24 Mile Lake containment structure, in its current configuration, that could lead to uncontrolled release of tailings or water, nor result in offsite impacts.

[1] Engineer of Record – Approved Designate: the appointed alternate if the EoR is not available. The role and scope of activities which can be undertaken on behalf of the EoR are defined in the OMS manual (THVCP 2018).

The L-L Dam is a cycloned sand dam with a glacial till core which extends vertically from the glacial till starter dam. The dam has been raised above the starter dam using the centreline method. Above El. 1220 m, a wider compacted sand zone is present between the beach and core. The layout of the L-L Dam and associated structures is shown in Figure 2. Refer to Appendix III-A for select design drawings and typical cross sections. At the end of 2018, the crest elevation of the L-L Dam is 1262.5 m, corresponding to a maximum downstream slope height (crest to toe) of about 161.5 m. The currently permitted ultimate crest of the L-L Dam is El. 1279 m, which corresponds to a maximum height of 178 m at the same location.

The L-L Dam has been assigned an “Extreme” consequence category and the H-H Dam a “Very High” consequence category, as defined by CDA (2013). The downstream seepage dams at the toe of the L-L Dam have been assigned a “Significant” consequence category. 24 Mile Lake has been assigned a “Low” consequence category, as defined by CDA (2013). There were no material changes in the characterization of key geotechnical or hydrotechnical hazards for the existing structure during 2018.

The most recent dam safety review (DSR) of the Highland TSF was completed by Stantec in 2017 (Stantec 2018). Stantec (2018) did not reveal any unsafe or unacceptable conditions in relation to design, construction, maintenance and operation of the dams. Recommendations made by Stantec (2018) and a summary of the current status is included in Appendix X. Based on the work done to date: 11 of the recommendations have been closed; 14 of the recommendations will be addressed by work currently in progress; and work to address the remaining 5 recommendations has been planned but not currently in progress.

The Code requires a DSR be conducted at a minimum every five years for TSFs, irrespective of dam consequence classification (MEM 2016). Therefore, the next DSR should be initiated no later than 2022.

During 2018, planned crest raises was completed at both the L-L Dam and H-H Dam. The work included: excavation of slimes and backfilling of Slimes Pond 1 and backfilling of Seepage Pond 1; foundation and abutment preparation; placement of drainage blanket and underdrains on the prepared foundation at L-L Dam; and fill placement, including raising of the till core zones.

There were no event-driven inspections or other dam safety issues of concern during 2018. The instrumentation data set that must be managed for the L-L Dam and H-H Dam is significant and includes more than 310 instruments. A continual improvement focus of 2018 was the ongoing dam surveillance tools and processes which included: installation of additional instrumentation; further development of the remote monitoring system; applying inclinometer corrections; implementation of a revised Trigger-Action-Response-Plan (TARP); and improved data management processes.

The Operation, Maintenance and Surveillance (OMS) manual was updated in 2018. The manual meets the intent of the Mining Association of Canada (MAC 2011) and CDA (2014) guidelines, is current and provides adequate coverage for existing conditions. A trial exercise of the Emergency Preparedness and Response Plan (EPRP) was completed by THVCP, with KCB participation. The main learnings from the trial will be incorporated into the 2019 updates of the EPRP and OMS manual.

THVCP commissioned a Failure Modes and Effects Analysis (FMEA) risk assessment for the L-L Dam and H-H Dam which was facilitated by the Wood Group and KCB also participated. The FMEA was completed over a series of workshop and follow up discussions in December 2017 to January 2018. The assessment included a review of design and operation controls for each of the dam safety failure modes. Based on the FMEA, the current failure mode risks were found to be well understood and well managed. The FMEA summary document is in progress and will be issued in 2019.

A component of the ongoing H-H Dam design review included a review of historic information which indicated the downstream shell fill is not all "rockfill" and has wide variation in waste type and gradations, including sand and gravel zones. Subsequent 2017 investigations at the H-H Dam confirmed the presence of loose sands and/or sands and gravels within the dam fill which may be susceptible to liquefaction if saturated. a stability assessment of the post-earthquake condition based on conservative assumptions indicates an acceptable factor of safety for existing conditions. Work is ongoing to confirm whether additional buttressing of the H-H Dam is required under a future loading condition to meet post-earthquake stability criteria.

The Highland TSF appears in good physical condition and the observed performance during the 2018 site inspections is consistent with the expected design conditions and past performance. The status of recommendations to address deficiencies and non-conformances identified during past DSIs are summarized in Table 1. Closed recommendations are shown in *italics*. Recommendations to address deficiencies and non-conformances identified during the 2018 DSI are summarized in Table 2.

Table 1 Status of Outstanding Recommendations for Deficiencies and Non-Conformances

ID No.	Recommended Action	Priority[1]	Recommended Deadline (Status)
L-L Dam			
LL-2015-01	*Downstream sand should be placed in over-steepened upper sections of the downstream dam slopes (between Sta. 1+050 m and Sta. 3+650 m) to the design (2.5H:1V) during the next construction season. Some re-work of the existing loose sand on these slopes will be required as the downstream sand is raised, to ensure these slopes meet compaction/density requirements.*	*3*	*CLOSED (design slopes established during 2018 construction)*
LL-2015-02	*The overflow lines from the secondary cyclones were buried with un-compacted cycloned sand across the upstream S2 zone during 2015. This sand will require re-working following completion of downstream sand placement during the next construction season.*	*3*	*CLOSED (pipes were removed during 2018 construction)*
LL-2015-06	We recommend that key design criteria for the Highland TSF, including the probable maximum flood (PMF), freeboard requirements and seismic ground motions be reviewed during 2016.	4	OPEN (Seismic hazard assessment update completed in 2018. PMF review in progress, to be finalized in 2019)
LL-2016-02	Install seepage measurement weirs at the outflow points of the North Dam (Sta. 3+600) and South Dam (Sta. 1+100) major drains to monitor seepage rates.	3	OPEN (*Locations to be defined in 2019 as part of Seepage Pond 4 design*)

ID No.	Recommended Action	Priority[1]	Recommended Deadline (Status)
H-H Dam and 24 Mile Lake			
None			
L-L Dam Seepage Collection and Slimes Ponds			
SP-2017-01	The Seepage Water Reclaim Pond has insufficient capacity to store the IDF and should be brought into compliance. Note: THVCP to include an interim plan involving pumping to manage the IDF without off-lease discharge until upgrade works are complete. Suggested interim milestones: Design in 2018, Permit and IFC in 2019 and Construction in 2020. *(Schedule updated in 2018)*	2	OPEN (In 2018 the design for upgraded pond was submitted for permit approval. Construction has been added to life-of-mine construction plan. To be completed by end of 2021.)
SP-2017-02	Regrade Seepage Pond 2 outlet pipe to a consistent downward grade	2	OPEN (Work scheduled for 2019 as part of Seepage Pond 2 slimes clean-out)

Notes:
1. Recommendation priority guidelines, specified by Teck and assigned by KCB:
   Priority 1: A high probability or actual dam safety issue considered immediately dangerous to life, health or the environment, or a significant risk of regulatory enforcement.
   Priority 2: If not corrected could likely result in dam safety issues leading to injury, environmental impact or significant regulatory enforcement; or, a repetitive deficiency that demonstrates a systematic breakdown of procedures.
   Priority 3: Single occurrences of deficiencies or non-conformances that alone would not be expected to result in dam safety issues.

Table 2 2018 Recommendations for Deficiencies and Non-Conformances

ID No.	Deficiency or Non-Conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority[1]	Recommended Deadline (Status)
L-L Dam					
LL-2018-01	Various	-	Review, complete and/or provide written response to close out all 2017 DSR recommendations.	3	Q1 2020
H-H Dam and 24 Mile Lake					
HH-2018-01	Various	-	Review, complete and/or provide written response to close out all 2017 DSR recommendations.	3	Q1 2020
HH-2018-02	Post-earthquake	10.1.8	Complete H-H Dam design review to confirm liquefaction susceptibility and dam stability under future loading conditions	2	Q4 2019
L-L Dam Seepage Collection and Slimes Ponds					
SP-2018-01	OMS	10.5.2	If Slimes Pond 4 to remain as contingency slimes storage, include it in the 2019 OMS manual update.	3	Q4 2019

Notes:
1. Recommendation priority guidelines, specified by Teck and assigned by KCB:
   Priority 1: A high probability or actual dam safety issue considered immediately dangerous to life, health or the environment, or a significant risk of regulatory enforcement.
   Priority 2: If not corrected could likely result in dam safety issues leading to injury, environmental impact or significant regulatory enforcement; or, a repetitive deficiency that demonstrates a systematic breakdown of procedures.
   Priority 3: Single occurrences of deficiencies or non-conformances that alone would not be expected to result in dam safety issues.
   Priority 4: Best Management Practice – Further improvements are necessary to meet industry best practices or reduce potential risks.

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1 INTRODUCTION

Klohn Crippen Berger Ltd. (KCB) was engaged by Teck Highland Valley Copper Partnership (THVCP) to complete the 2018 dam safety inspection (DSI) of the Highland Tailings Storage Facility (TSF) on the Highland Valley Copper (HVC) mine site, as shown in Figure 1. Tailings from ongoing mining operations are discharged into the Highland TSF. Tailings are retained in the impoundment by two containment dams (L-L Dam and H-H Dam) which are incrementally raised to meet tailings storage requirements, typically on an annual basis.

The scope of this report includes: L-L Dam and the Seepage Collection and Slimes Ponds at the downstream toe; H-H Dam and 24 Mile Lake at the downstream toe.

The scope of work consisted of:

- a visual inspection of the physical conditions of the various containment facilities;
- a review of updated piezometer, inclinometer and seepage monitoring data provided by THVCP;
- a review of climate and water balance data for the site;
- a review of other relevant dam safety management documents (e.g. Operations, Maintenance & Surveillance (OMS) manual); and
- a review of the past year's construction records.

The inspection and this report were prepared to comply with Section 10.5.3 of the Health, Safety and Reclamation Code for Mines in British Columbia (the Code), Section 4.2 "Annual Tailings Facility and Dam Safety Inspection Report" of the Code Guidance Document (MEM 2016).

The visual inspection was completed by the Engineer of Record (EoR), Mr. Bill Chin, P.Eng. and Engineer of Record – Approved Designate[2] (EoR-AD), Mr. Rick Friedel P.Eng., P.E., both as representatives of KCB on September 11, 2018. The weather during the DSI was clear and sunny and did not impact the visual inspection. Both Mr. Friedel and Mr. Chin made multiple trips to site during 2018 to support construction and other activities related to the Highland TSF. Mr. Chris Anderson, P. Eng., THVCP Manager, Tailings and Water is the TSF Qualified Person (as defined by the Code) for the Highland TSF.

The Highland TSF is operated under the following permits:

- British Columbia Ministry of Energy, Mines and Petroleum Resources (EMPR) Geotechnical Permit M11 – the permit covers the entire mine life, property and the surrounding area and communities. This permit was last amended in 2011, approving the Lornex Pit expansion, the new South Side Tailings Distribution System and raised ultimate crest elevations of H-H Dam

[2] Engineer of Record – Approved Designate: the appointed alternate if the EoR is not available. The role and scope of activities which can be undertaken on behalf of the EoR are defined in the OMS manual (THVCP 2018).

and L-L Dam. Section B 2 of the permit lists the conditions concerning dam safety at Highland TSF.

- British Columbia Ministry of Environment (MOE) Water Licenses 46527 and 46528 – these licenses allow diversion and storage of water from Pukaist Creek on Crown Land.
- British Columbia MOE Effluent Permit PE-376 – this permit allows the storage of tailings and effluent in the Highland TSF.

The L-L Dam and H-H Dam have been assigned an "Extreme" consequence classification and a "Very High" consequence classification, respectively, in accordance with the Code which refers to the Canadian Dam Association (CDA) Dam Safety Guidelines (CDA 2013). These classifications remain unchanged in 2018 and were reviewed during a dam consequence review hosted by THVCP on January 23, 2019, which the EoR-AD (Mr. Rick Friedel, P.Eng. of KCB) participated in via teleconference. The classifications were subsequently reviewed and agreed by the EoR (Mr. Bill Chin, P.Eng. of KCB). A summary list of the consequence classifications assigned to each of the supplementary dams downstream of the main dams is provided in Section 2.

The Code recommends a dam safety review (DSR) be undertaken every 5 years based on the "Extreme" consequence classification of L-L Dam and "Very High" consequence classification for the H-H Dam. The other dams at the facility with lower consequence classifications have previously been included in the Highland TSF DSR. The most recent DSR for the Highland TSF dams was carried out by Stantec starting in 2017 with final report issued in June 2018 (Stantec 2018). The next DSR should be scheduled for, no later than, 2022.

Note that there are two sets of figures in this report, one set is at the end of the report numbered 1 to 5. The other set is in the body of the report with numbering by section and order, e.g. 7.1.

2 FACILITY DESCRIPTION

The Highland Valley Copper Mine, owned and operated by THVCP, is located near Logan Lake, approximately 45 km southwest of Kamloops, in the interior of British Columbia, as shown in Figure 1. The Highland TSF is located approximately 6.5 km northwest of the operating mill.

The tailings are retained in the Highland TSF by the L-L Dam (west end) and H-H Dam (east end) which were constructed across either end of the Highland Valley. Construction of the Highland TSF began in 1971 with the J-J Starter Dam, which was located approximately half-way between the H-H Dam and the L-L Dam. In 1972 the H-H Starter Dam was constructed, followed by the L-L Starter Dam between 1976 and 1979. By 1991 the J-J Dam was buried by tailings. A summary of design and construction history for the L-L Dam and H-H Dam are included in Appendix III.

The L-L Dam is a cycloned sand dam with a glacial till core which extends vertically from the glacial till starter dam. The dam has been raised above the starter dam using the centreline method. Above El. 1220 m, a wider compacted sand zone is present between the beach and core. The layout of the L-L Dam and associated structures is shown in Figure 2. Refer to Appendix III-A for select design drawings and typical cross sections. As of the end of 2018, the crest elevation of L-L Dam is 1262.5 m, corresponding to a maximum downstream slope height (crest to toe of Valley Buttress Berm at El. 1105 m) of about 157.5 m. The currently permitted ultimate crest of the L-L Dam is El. 1279 m, which corresponds to a maximum height of 174 m at the same location.

The H-H Dam is a pit waste dam with a glacial till core which extends vertically from the glacial till starter dam. The dam has been raised above the starter dam using the centreline method, similar to L-L Dam, with the upstream portion of the core supported by beach tailings. The beach tailings at H-H Dam are coarser than those present at L-L Dam because of proximity to the spigot points. The layout of the H-H Dam and associated structures is shown in Figure 4. Refer to Appendix III-B for select design drawings and typical cross sections. As of the end of 2018, the crest elevation of H-H Dam ranged from El. 1273 m to 1280 m, corresponding to a maximum downstream slope height (crest to toe) of about 50 m. The dam height above original ground measured at the centerline is approximately 90 m but the waste dumps have elevated the existing ground downstream of the dam (~40 m) which reduces the slope height.

The tailings beach slopes from the primary discharge points at the H-H Dam towards the pond near the L-L Dam which is ~9 km away. Therefore, no significant ponding occurs at the H-H Dam. The profile of the crest along the dam alignment is sloped to match the forecast beach profile immediately upstream of the dam. The currently permitted ultimate crest of the H-H Dam is El. 1292.7 m to El. 1298 m, which corresponds to a maximum downstream slope height of approximately 67 m through the midpoint of the dam.

Seepage, surface runoff and overflow from the slimes ponds at the L-L Dam report to either Seepage Pond 2 or the Seepage Water Reclaim Pond (SWRP). Seepage Pond 2 overflow discharges to the SWRP where water is subsequently pumped back to the Highland TSF impoundment via the seepage water reclaim pipeline.

Tailings suspended in the overflow water from the hydraulic placement cells during construction of L-L Dam is referred to as “slimes” because the material typically comprise the finer grained fraction of the cycloned sand fill. The overflow water and slimes are conveyed via pipe from the placement cell to the various slimes storage ponds. The accumulated slimes in the slimes storage ponds are periodically excavated and transported to the impoundment for disposal on an as needed basis.

Two slimes ponds located near the downstream toe of the L-L Dam (Slimes Pond 2 and Slimes Pond 4) were used in 2018. Slimes Pond 4 was noted as decommissioned in the 2017 DSI (KCB 2018a) and was not planned to be used in 2018. However, the facility was re-activated to help manage a shortfall in slimes storage capacity due to delays in construction of Slimes Pond 3 and a higher than typical slimes production rate. There were no geotechnical restrictions which prevented Slimes Pond 4 from being used for this purpose. Slimes were also stored in Seepage Pond 2 and temporary on-dam cells utilized to manage this shortfall as discussed in Section 3.2.2. THVCP plan to maintain Slimes Pond 4 as a contingency slimes storage until it is taken out of service to allow construction of Seepage Pond 4. Slimes Pond 4 is not included in the current OMS manual and should be added in the next update. THVCP plan to remove slimes from Seepage Pond 2 and reinstate the pond to the pre-2018 conditions.

In 2018, stored slimes accumulated from previous hydraulic cell construction were removed from Slimes Pond 1 and the pond backfilled with compacted sand and gravel. During the slimes excavation, lacustrine and glaciolacustrine sediments were also excavated from the base of the original pond.

The 24 Mile Lake facility area was formally a natural lake that is now surrounded by waste dumps with no clearly defined dam structure. The facility is downstream of the H-H Dam, physically separate from the Highland TSF, and collects seepage from the H-H Dam as well as emergency tailings disposal from the H-H Pumphouse during periods of tailings line maintenance and/or operational upsets. The layout of the H-H Dam and 24 Mile Lake are shown in Figure 4. KCB completed an assessment at the request of THVCP to review the potential for declassifying 24 Mile Lake facility as a “dam” under the Code (KCB 2018b) which concluded:

- There is no credible failure mode for the 24 Mile Lake containment structure, in its current configuration, that could lead to uncontrolled release of tailings or water, nor result in offsite impacts. As such, 24 Mile Lake could be declassified as a dam from a regulatory reporting perspective and continue to be managed as an appurtenance of the H-H Dam. The current stewardship roles and responsibilities should be maintained.

Pertinent information on the dam structures at the Highland TSF and supplementary structures are included in Table 2.1. Further descriptions for the L-L Dam, H-H Dam and 24 Mile Lake are provided in the subsequent sections of the report. A schematic of the tailings and water management system is shown on Figure 2.1.

Refer to Appendix III for an overview of the L-L Dam and H-H Dam and history.

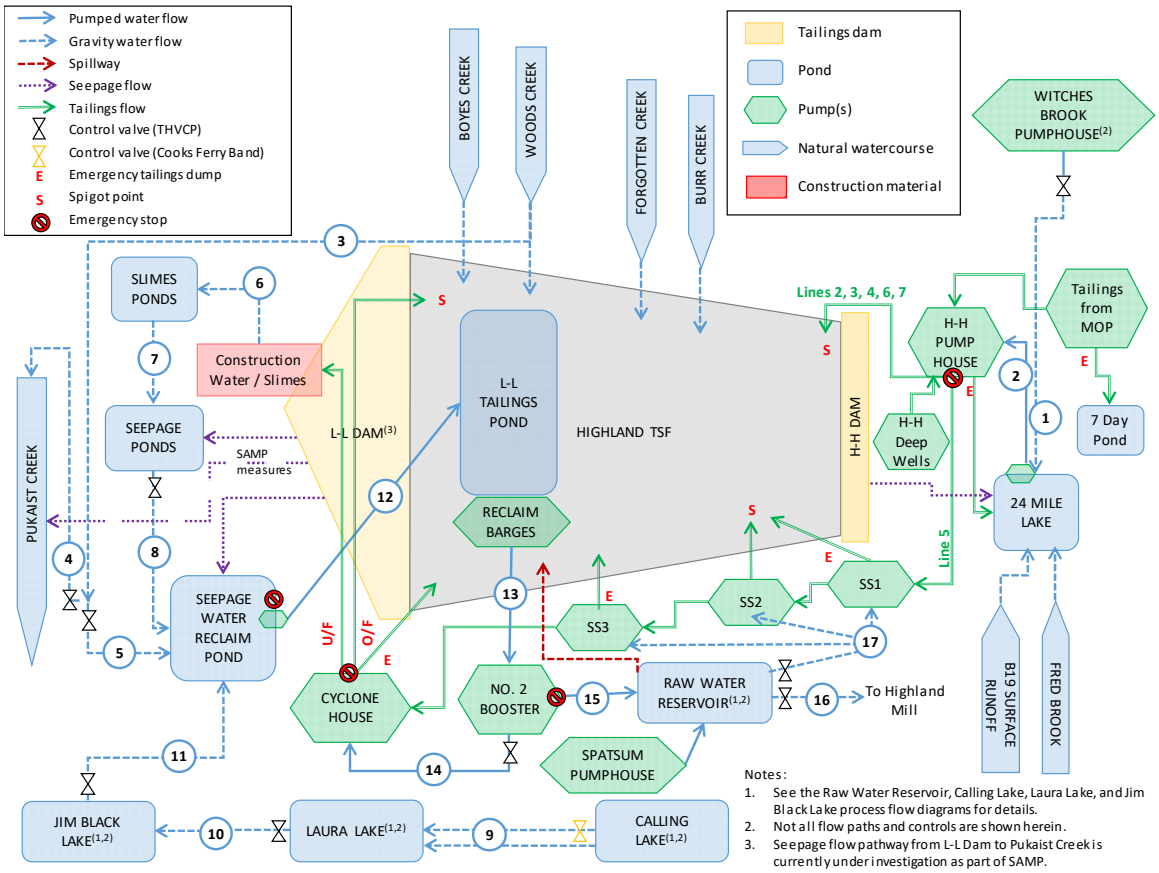
Table 2.1 Containment Facilities at the Highland TSF

Dam / Facility	Consequence Classification[1]	Purpose	Construction	Current Est. Crest Length (m)	Current Est. Crest El. (m)	Current Est. Max Downstream Slope Height (m)
L-L Dam	Extreme	Contains the Highland TSF at its downstream (western) limit.	Earthfill starter dam that has been raised using centreline method of construction with a downstream zone of compacted cycloned sand, a centreline vertical till core, and a sand and gravel drainage blanket beneath the downstream shell of the dam.	3,050	1262.5	161.5
H-H Dam	Very High	Contains the Highland TSF at the upstream (eastern) limit.	Earthfill starter dam that has been raised using the centreline method of construction, with a downstream zone of variable mine waste and a centreline vertical core.	1,900	1273 to 1280	~55
24 Mile Lake	Low[1,2]	Receives seepage from the H-H Dam and emergency tailings disposal from the H-H Pumphouse during maintenance of the tailings lines and/or operational upsets.	A former natural lake surrounded by waste dumps.	n/a	Min. 1220 (waste dumps)	n/a (Note 3)
Seepage Water Reclaim Pond	Significant	Part of the reclaim system, which pumps water back to the TSF. Receives water from surface runoff, the slimes ponds and the seepage collection ponds.	Original embankment on the west side of pond is homogeneous glacial till with downstream sand and gravel filter. Pond is unlined.	95	1103.2	5
Seepage Pond 1	n/a (decommissioned)	Collects seepage from the toe of the VBB at the L-L Dam. Pond is unlined.	Excavated into natural ground with an embankment constructed of silty sand (possible Glacial Till) fill on the southwest side. The northeast side of the pond is formed by the sand and gravel drainage blanket to the VBB. Pond is unlined. In 2018, the pond was backfilled as part of L-L Dam foundation preparation and is now buried.	500	1104	3

Dam / Facility	Consequence Classification[1]	Purpose	Construction	Current Est. Crest Length (m)	Current Est. Crest El. (m)	Current Est. Max Downstream Slope Height (m)
Seepage Pond 2	Significant	Collects seepage primarily from finger drains under the NBB at the L-L Dam.	Excavated into natural ground on three sides, with a homogenous glacial till embankment on the north side of the pond. Pond is lined with geomembrane.	80	1116.6	1.8
Slimes Pond 1	Significant	Was used to collect construction water and fines from hydraulic sand placement on the downstream side of L-L Dam prior to the construction of Slimes Pond 2.	Excavated into natural ground with homogeneous glacial till embankment on the northeast (NE) and southwest (SW) sides. Pond is unlined.	NE = 500 SW = 700	1103.2	2.5 to 3.75 m
Slimes Pond 2	Significant[1]	Collects construction water and fines from hydraulic sand placement on the downstream side of L-L Dam.	Excavated into natural ground on three sides, with a homogeneous glacial till embankment on the south side. Pond is lined with geomembrane.	100	1126.9	10
Slimes Pond 4	n/a [5]	In 2017, this pond was noted as decommissioned but was reinstated in 2018 during construction to collect construction water and fines from hydraulic sand placement on the downstream side of L-L Dam	Slimes Pond 4 contained by natural ground with small compacted till embankments to provide containment at the south and southeast ends. The embankments are separating berms to promote sediments to drop out of suspension before flowing into SWRP.	n/a	1103 to 1104	<2 m

Notes:
1. As assigned during the Dam Classification Workshop held in January 2018.
2. Assessed in late 2017 for potential to be declassified as a dam under the Code (KCB 2018c).
3. 24 Mile Lake downstream slope – The relatively flat, more than a kilometer-wide containment structure that separates 24 Mile Lake from the Valley Pit does not pose a static or dynamic stability concern that could result in an uncontrolled release (KCB 2018c).
4. Slimes Pond 3 was included in this table during 2017 as “under construction,” but has been removed in 2018 as construction of the pond is not yet complete and facility not in use.
5. The crest of the divider dykes are below the surrounding natural ground. Failure of any of the divider dykes would be internal to the pond only with no downstream impacts.

Figure 2.1 Process Flow Diagram for Highland TSF



Notes:
1. See the Raw Water Reservoir, Calling Lake, Laura Lake, and Jim Black Lake process flow diagrams for details.
2. Not all flow paths and controls are shown herein.
3. Seepage flow pathway from L-L Dam to Pukaist Creek is currently under investigation as part of SAMP.

No.	Name	Description	Status
1	Roman Road Pipeline	1x 20" HDPE pipeline	Operational
2	Dewatering to H-H Pumphouse	1x 12" HDPE pipeline	Operational
3	Woods Creek Diversion	System consists of: i) riprap-lined collection pond below Highway 97c; ii) Pumphouse and motor control center buildings; iii) 7 km HDPE pipeline (dia. varies) to Pukaist Creek; and iv) 2x 500 mm dia. HDPE pipes with knife gate valves for discharge to either SWRP or Pukaist Creek.	Operational
4	Woods Creek Diversion to Pukaist Creek	1x 500 mm dia. HDPE pipeline with knife gate valve	Operational
5	Woods Creek Diversion to SWRP	1x 500 mm dia. HDPE pipeline with knife gate valve	Operational
6	Construction Water / Slimes to Slimes Ponds	Gravity flow of water and slimes from one or more hydraulic cyclone sand cells during construction.	Operational during construction
7	Slimes Ponds to Seepage Ponds	Slimes Pond 1 drains to SWRP, and Slimes Pond 2 drains to Seepage Pond 2.	Operational
8	Seepage Pond 2 Outlet	1x 36" dia. HDPE pipe graded upward for the first 12.1 m, then downward for the next 44 m to the SWRP with control valve	Operational
9	Low-Level Outlet and Spillway (Calling Lake)	Low-level outlet: 12" dia. HDPE pipe with control valve and submerged intake trash rack. Spillway: 12' wide channel.	Operational
10	Diversion Outlet (Laura Lake)	12" dia. HDPE pipe with control valve and intake trash rack	Operational
11	Jim Black Diversion to SWRP	Open channel with U/S y-valve	Operational
12	SWRP to TSF	2x permanent pumps in the Seepage Water Reclaim Pond pumphouse feeding 2x 18" dia. HDPE pipelines to the L-L Pond	Operational
13	Reclaim Barges	#1 and #2 Reclaim Barges on the south side of the L-L Pond	Operational
14	Bypass via Reclaim Isolation Valve	Bypass line controlled by hydraulic valve	Operational
15	Reclaim to Raw Water	2x 36" dia. HDPE pipelines from No. 2 Booster to Raw Water Reservoir	Operational
16	Raw Water to Mill	Consists of Low-Level Outlet at East Dam (2x HDPE pipelines with control valves) and #3, #4 Reclaim (2x HDPE pipelines with control valves)	Operational
17	South Side Tailings Gland Water System	1x 10" HDPE pipeline	Operational

3 2018 OPERATIONS

3.1 Tailings Deposition and Available Storage

Permit PE-376 states that the maximum authorized daily rate of discharge into the Highland TSF is 518,000 m^3/day. The maximum annual average rate of discharge is 282,000 m^3/day. In 2017, THVCP revised the calculation for estimating this discharge rate to account for tailings pond water reclaim to the Mill (THVCP 2017).

Tailings from the Mill are pumped to the H-H Dam Pumphouse and the majority of tailings are then pumped to the primary discharge point upstream of the H-H Dam east (left[3]) abutment. The remaining tailings are pumped to the Cyclone House at the L-L Dam via the South Side Tailings System (SSTS). The Cyclone House is located close to the south (left) abutment of the L-L Dam (Figure 3.1). Tailings slurry entering the Cyclone House is pumped through the primary cyclones. Overflow from the primary cyclones is discharged in the tailings impoundment. During construction, underflow from the primary cyclones is sent to the secondary cyclones on the dam crest and discharged into the impoundment during other periods.

The main elements of the tailings distribution system are shown on Figure 3.1. Tailings discharge into the Highland TSF during 2018 is summarized in Table 3.1. During 2018, approx. 50 Mt were discharged from L-L Dam for beaching, refer to Table 3.1 for tonnage breakdown.

[3] Left and right convention used throughout the report based on looking in a downstream direction at that structure.

Figure 3.1 Plan View of South Side Tailings System

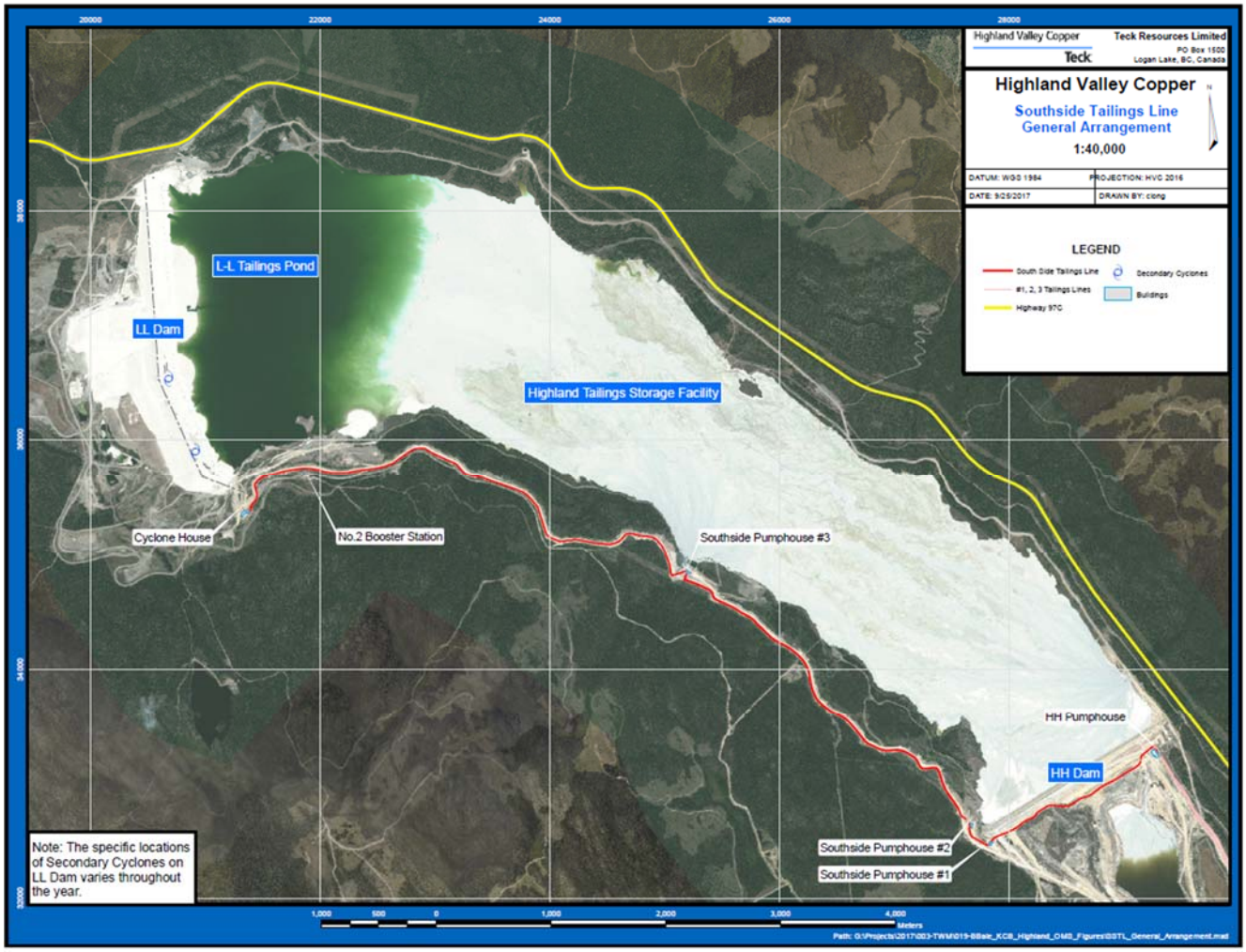


Table 3.1 Summary of 2018 Tailings Distribution into Highland TSF

Spigot Location	Tailings Discharged (Dry tonnes)
H-H Dam: East Abutment[1]	31,146,000
H-H Dam: West Abutment (SS2)	840,000
Mid-Impoundment (SS3) + Cyclone House Bypass	4,089,000
L-L Dam Cyclone House – 2018 construction[2]	13,910,000
Total 2018 Tailings:	49,985,000

Notes:
1. Excludes tailings deposited into 24 Mile Lake.
2. Includes tailings that report as slimes to collection ponds / cells which are relocated into Highland TSF impoundment.

3.2 2018 Main Construction Activities

3.2.1 Summary

During 2018, the Highland TSF 2017-2019 Construction contract continued with the next planned crest raises and associated downstream fill placement at both the L-L Dam and H-H Dam. The contract comprises of the following:

- North American Construction Group (NACG) have been contracted by THVCP to complete construction (excluding hydraulic sand placement) and provide Quality Control (QC) services for all work (subcontracted to Allnorth).
- Lake Excavating Ltd., now referred to as Nhwelmen-Lake, (N-L) have been contracted by THVCP to carry out hydraulic cycloned sand placement activities.
- KCB are contracted by THVCP to provide Quality Assurance (QA) services and prepare construction record report (KCB 2019).
- THVCP are responsible for contract management, construction supervision and supply/delivery of cycloned sand.

The construction activities listed below were completed in 2018 and are documented in the 2018 construction summary report (KCB 2019).

3.2.2 L-L Dam

During 2018, works included the following:

South Dam (Sta. 0+900 to Sta. 1+200)

- Foundation preparation including stripping of unsuitable materials (organics, non-compliant fill, etc.) in preparation for fill placement.
- Placement of sand and gravel (SG1) and construction of a minor drain to form the drainage blanket out to the Ultimate Dam footprint.
- Placement of hydraulic cycloned sand fill (S1 and S2) to El. 1262.5 m between Sta. 0+900 and Sta. 1+200 and completion of the southern half of the South Buttress Berm.

Valley Buttress Berm (VBB) and Valley Buttress Berm Extension (VBBE) (Sta. 1+200 to Sta. 2+400)

- Foundation preparation at the toe of the VBB which comprised of:
  - excavation of slimes (and lacustrine and glaciolacustrine deposits where present) from Slimes Pond 1;
  - stripping of unsuitable materials (organics, non-compliant fill, etc.) from the footprint of the area proposed for S1 fill in 2019;

  - excavation of slots within the existing till wrap on the downstream slope of the dam between Sta. 1+600 and Sta. 2+000 to expose underlying S1 fill (in lieu of full removal of the till wrap); and
  - removal of the existing till wrap on the downstream slope of the dam (where < 1m thick) between Sta. 1+500 and Sta. 1+600, up to El. 1141 m;
- Backfilling of Slimes Pond 1 with SG1 fill to El. 1102 m;
- Backfilling of Seepage Pond 1 with SG1 fill to El. 1108 m;
- Placement of SG1 to form the drainage blanket out to the Ultimate Dam footprint;
- Placement of hydraulic S1 and S2 fill on the upper part of the downstream slope to the target El. 1262.5 m between Sta. 1+200 and Sta. 2+400. Target fill elevation was not achieved between Sta. 2+100 and Sta. 2+400; instead, fill was placed to minimum of El. 1246.5 m which was adequate to support the El. 1262.5 m crest raise; and
- Placement of S1 fill on the lowest bench of the VBBE between Sta. 2+200 to Sta. 2+400.

North Buttress Berm (NBB) (Sta. 2+400 to Sta. 2+800)

- Placement of hydraulic S1 and S2 fill on the upper bench of the NBB to El. 1262.5 m.

North Dam (Sta. 2+800 to Sta. 3+700)

- Foundation preparation along the toe of the North Dam which comprised of:
  - stripping of unsuitable materials (organics, non-compliant fill, etc.) from the existing dam toe to the Ultimate Dam footprint between Sta. 2+800 and Sta. 3+300; and
  - excavation to a maximum depth of El. 1234 m to remove the Upper-Glaciolacustrine deposits between the toe of the existing dam and Ultimate Dam toe between Sta. 3+300 and Sta. 3+700.
- Placement of SG1 to form the drainage blanket out to the Ultimate Dam footprint.
- Construction of a major drain and five minor finger drains between Sta. 3+700 and 3+200 within the drainage blanket.
- Placement of hydraulic S1 and S2 fill out to the Ultimate Dam toe and up to El. 1262.5 m. A minimum fill level of El. 1253 m was achieved between Sta. 3+450 and Sta. 3+700 which was greater than the minimum fill level required to support the El. 1262.5 m crest raise.

Dam Crest Raise

- Foundation preparation at the north and south abutments in preparation for the annual Till Core Raise.
- Placement of T1/T2 Glacial Till to raise the Till Core Zone to El. 1262.5 m.

- Placement of upstream S2 hydraulic fill between Sta. 2+350 and Sta. 2+700 to El. 1262.5 m. Completion of the remaining upstream S2 Zone raise to El. 1262.5 m was deferred and scheduled to resume in February 2019.
- The next scheduled milestone is to raise the crest to El. 1264.5 m by November 30, 2019 which is an additional 2 m above the current crest at El. 1262.5 m.

Hydraulic Cell Placement Slimes Management

- Volume of slimes produced from the hydraulic cycloned sand placement was found to be greater than from previous construction years. The volume of slimes generated varies based on several factors such as cyclone performance and cell retention time. Average slimes production, prior to 2018, was approximately 3% of cycloned sand volume. This value was used to estimate required slimes storage capacity for 2018 planning. However, actual slimes generation in 2018 was found to be as high as 5.5% of cycloned sand volume during periods of placement. The increase in slimes volume is likely the result of increased sand being washed out of the cells.
- In addition to an increased volume of slimes to manage, construction of Slimes Pond 3 was not completed in 2018, as scheduled, due to archeological clearance restrictions. This reduced the available slimes storage capacity below what had been assumed in planning.
- To manage this shortfall, THVCP stored slimes in Slimes Pond 4 and Seepage Pond 2 which were not previously planned for this use. THVCP also successfully trialed and implemented, following MEMPR approval, temporary on-dam slimes cells which were excavated into the dam fill at the VBBE and NBB (KCB 2018c, 2018e). The concept of on-dam slimes storage is similar to existing hydraulic sand placement except no dozer is operated in the cell during placement.
- As described in the 2018 permit report (KCB 2018d), THVCP are planning to implement temporary storage in on-dam cells as part of routine operations. KCB supports this path forward, provided the appropriate constraints are in place to prevent a significant impact to dam safety as agreed to by the EoR such as: minimum setback from the outer slope; maximum free-water pond depth; outlet pipe capacity and freeboard; and diligent surveillance requirements.

The construction activities were carried out in general accordance with the specifications and consistent with the design intent. Changes to the issued for construction (IFC) drawings, the specifications and/or clarifications/responses to Requests for Information from the Contractor or to incorporate improvement opportunities are documented in the construction record report (KCB 2019).

3.2.3 H-H Dam

During 2018, works included the following:

Dam Crest Raise

- To complete the raise started in 2017, the temporary fill placed at the west abutment during inclement weather at the end of the construction season was either removed or left in place based on QC tests and QA site observations.
- Foundation preparation was carried out at the West Abutment, including cleaning of shallow irregular surface of granodiorite bedrock.
- The upstream RF1/RF2 Zone, Till Core Zone and SG2 Zone were raised from West to East Abutment to between El. 1273 m and El. 1280 m.
- The profile of crest along the dam alignment was sloped between 0% and 0.9% to accommodate projected tailings beach elevations and maintain the minimum 1 m buffer based on spigot locations at the east and west abutments.

The construction activities were carried out in general accordance with the specifications and consistent with the design intent. Changes to the IFC drawings, the specifications and/or clarifications/responses to Requests for Information from the Contractor or to incorporate improvement opportunities are documented in the construction record report (KCB 2019).

3.3 2017 Dam Safety Review

The 2017 DSR was completed by representatives of Stantec Consulting Ltd. (Stantec) and issued in 2018 (Stantec 2018). No unsafe or unacceptable conditions were identified in relation to design, construction, surveillance, maintenance and operation of the dams. Stantec concluded that the dams at the Highland TSF comply with the 19 dam safety principles from CDA (2013).

Thirty (30) recommendations were made in the document:

- 29 of the recommendations were assigned a priority level[4] of 3 or 4 which represent an issue which on its own does not represent a dam safety concern or is a best practice activity. Several of these are related to consolidating information and documentation.
- 1 recommendation was assigned a priority level 2 which represent an issue that, if not further investigated or potential impacts, if any, managed could result in dam safety issue. The recommendation was in reference to completion of additional sensitivity analyses to further assess the potential impacts, if any, of core cracking on dam performance.

[4] Refer to priority levels listed for recommendation summary tables in Section 8.

A summary of the recommendations is included in Appendix X along with a status update. THVCP and KCB have agreed to the following path forward on each action:

- Based on the work done to date, 11 of the recommendations have been closed;
- 16 of the recommendations will be addressed by work currently in progress, most are tied to the ongoing design update review, including the core cracking sensitivity analysis; and
- Work to address the remaining three recommendations has been planned but not currently in progress.

DSR recommendations, work plan and status have been shared with the Highland TSF Tailings Review Board twice since the DSR was issued. The work plans to close out remaining DSR recommendations should be completed as agreed.

4 WATER MANAGEMENT

4.1 Overview

Water management at each structure and how they interact with each other is summarized below and shown graphically on Figure 2.1. Highland TSF

- Inflows include water from tailings slurry, precipitation on the pond, seepage return water pumped from the Seepage Water Reclaim Pond, seepage return water pumped from 24 Mile Lake, surface runoff from surrounding catchments, and inflows from Boyes Creek, Burr Creek, and Forgotten Creek all located on the northern side of the TSF:
  - A portion of flow from Woods Creek are now diverted away from the Highland TSF into Pukiast Creek downstream of the L-L Dam via the Woods Creek Diversion Scheme, which is part of the Pukiast Creek Sulphate Adaptive Management Plan (THVCP 2017).
- Outflows include seepage from both dams, reclaim water from two reclaim barges located on the south side of the impoundment near the L-L Dam which is pumped to the Raw Water Reservoir for reclaim to the Highland Mill and evaporation. The Highland TSF has no spillway and is designed to store the environmental design flood (EDF) and inflow design flood (IDF); refer to Section 4.4.

Seepage Pond 2

- Inflows typically include seepage from northern sections of the L-L Dam (via Finger Drain #1 which channels seepage from beneath the North Dam and North Buttress Berm), precipitation on the pond, runoff from upstream catchments, and decant water from Slimes Pond 2.
- As discussed in Section 3.2.2, Seepage Pond 2 was used to store slimes from hydraulic sand placement in 2018. In 2019, THVCP plan to remove the slimes and reinstate the prior condition and operation of the pond.
- There is no emergency spillway for this pond. Outflows are through a 900 mm (36”) outflow pipe located in the southeast corner of the pond and as evaporation. Outflows from the pond report to the Seepage Water Reclaim Pond.
- The outflow pipe is graded upward at 4.2% for the first 9.5 m and 0.6% for the next 2.6 m, then downward at 3.5% for the next 44 m to the outlet. A flow control valve is located along the upward 0.6% segment of pipe. Refer to Section 4.4 for further discussion on flood routing.

Slimes Pond 1

- Stored slimes were excavated from Slimes Pond 1 and the basin backfilled with compacted sand and gravel fill. Some flow still reports to Slimes Pond 1 area and pond locally before being pumped or discharged to SWRP.

Slimes Pond 2

- Inflows include construction water from hydraulic sand placement on the downstream side of L-L Dam, precipitation on the pond, and runoff from upstream catchments.
- There is no emergency spillway for this pond. Outflows include gravity flow through a 900 mm (36”) outflow pipe which is directed into Seepage Pond 2, evaporation and discharge via an underdrain pump which can be used to manually draw down the water level in the pond prior to slimes excavation.

Slimes Pond 4

- Inflows include construction water and slimes from hydraulic sand placement on the downstream side of L-L Dam, precipitation on the pond, and runoff from the small upstream catchment.
- The water level is maintained by the outflow pipe into SWRP which has a capacity greater than inflows from hydraulic cell placement and local catchment.

Seepage Water Reclaim Pond

- Inflows include seepage from the L-L Dam (via the UVD/LVD drain), seepage from Slimes Pond 1, outflow from Seepage Pond 2, outflow from Seepage Pond 1, outflow from Slimes Pond 4, outflow from Jim Black Lake, precipitation on the pond, water from the Sulphate Adaptive Management Plan (SAMP) interception wells, and runoff from upstream catchments.
- Outflows include seepage, reclaim pumping back to the impoundment via the seepage water reclaim pipeline which crosses the L-L Dam crest at the south abutment. There is no spillway for this pond which relies on pumping to manage the IDF, as discussed in Section 4.4.

24 Mile Lake

- Inflows include water from tailings slurry from the H-H Pumphouse, seepage from the H-H Dam, precipitation on the pond, and runoff from upstream catchments.
- Outflows include seepage that discharges to the Valley Pit, and reclaim water pumped to the H-H Pumphouse via a portable pump located on the east side of the facility. There is no spillway for this facility.

4.2 Climate

THVCP provided weather data from the L-L Dam climate station (El. 1186 m). In 2018, some data logger issues in June, September and November led to some short data gaps as noted in Table 4.1. To support key precipitation trends and impacts on observed dam performance in 2018 data from Kamloops Airport (Environment Canada Station No. 1163781, El. 345 m) was reviewed for comparison that no major events were missed and general trends were consistent. Precipitation records at L-L Dam and Kamloops Airport are tabulated and plotted with average monthly values or climate normals in Table 4.1 and Figure 4.1, respectively.

Seasonal snowpack depth is not measured at the L-L Dam weather station. Instead, monthly measurements at the Highland Valley snow survey station (Station No. 1C09A) near the Trojan TSF are used to track the changes in snowpack. Historical average and 2018 snowpack depths based on available records are summarized in Table 4.2.

The following observations were noted for 2018:

- April was noticeably wetter than normal which coincides with an above average freshet pond level rise in 2018 (see Section 5.3.1). The pond rise was also influenced by the Lornex Pit dewatering project.
- SWE measured from March 1 to May 1 were significantly (up to +520%) deeper than average. The drier than normal month may have offset a portion of the melt-induced flows during freshet; however, impact of freshet could have also been less due to improvements made by THVCP following 2017 freshet.

Table 4.1 Monthly Precipitation

Month	Precipitation (mm)			
	2018 at L-L Dam	Average Monthly at Main Area[1]	2018 at Kamloops Airport[2]	1981-2010 Climate Normals at Kamloops Airport[2]
January	19.8	27.5	23.7	21.1
February	26.9	21.0	51.9	12.4
March	16.7	16.7	19.6	12.8
April	80.5	21.3	42.8	14.2
May	12.9	41.3	2.4	27.3
June	48.6 [3]	47.9	36.8	37.4
July	37.0	43.5	35.7	31.4
August	41.6	31.7	19.2	23.7
September	54.2 [4]	31.2	50.5	29.4
October	20.3	30.0	27.5	19.4
November	22.2	40.4	33.5	23.3
December	14.8	40.8	20.2	25.4
Annual Total	395.5	393.3	363.8	277.6

Notes:
1. Estimated by Golder (2016) using appropriate adjustment factors and average precipitation measured at Highland Valley Lornex climate station (Environment Canada ID No. 1123469 at El. 1268 m).
2. 2018 data from relocated station (ID No. 1163781); climate normals from data collected at previous station location (ID No. 1163780).
3. Data missing from June 6 to June 24 and June 26 to June 31, inclusive.
4. Data missing from September 21 to September 30, inclusive.

Figure 4.1 Monthly Precipitation

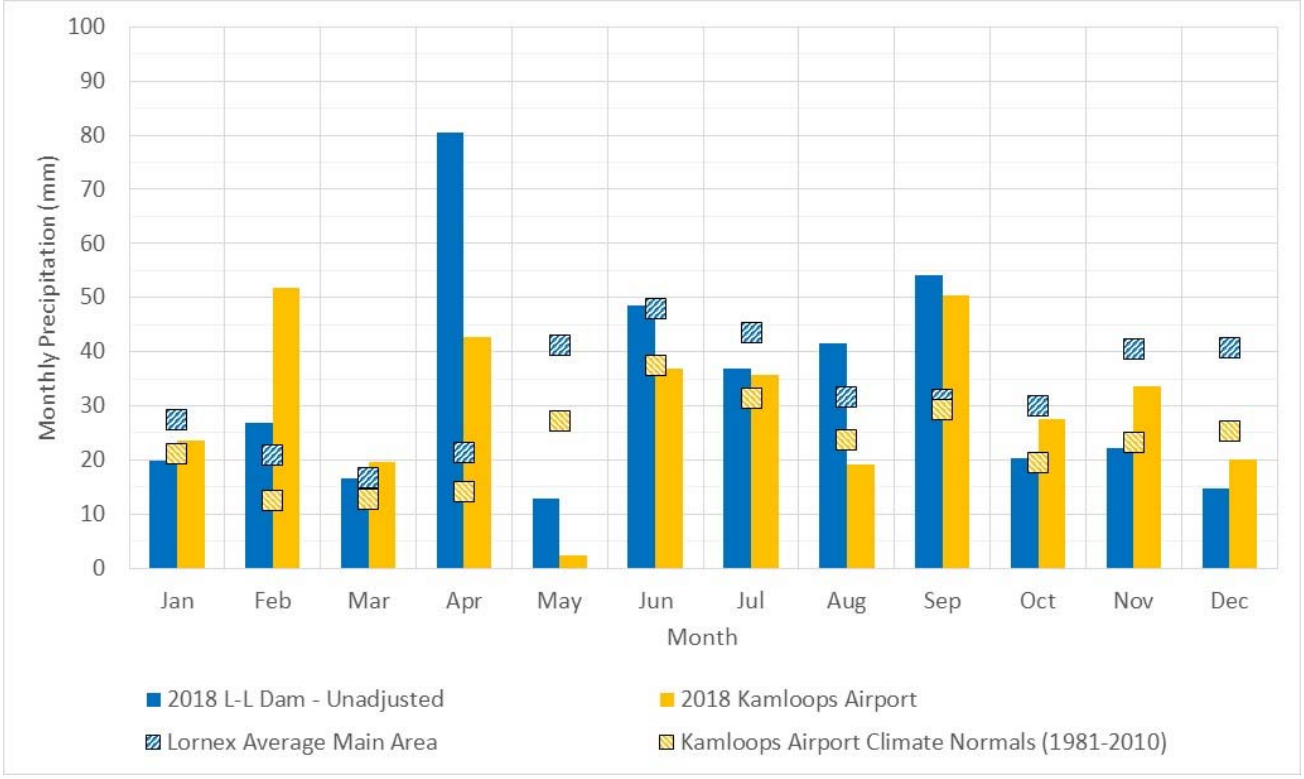


Table 4.2 Historical Average and 2018 Snowpack Depths

Survey Period	Years of Record[1]	Historic Average Snowpack Depth[2] (mm SWE[3])	2018 Snowpack Depth (mm SWE[3])	Percent Difference
January 1st	11	50.2	Not surveyed	N/A
February 1st	25	83.5	Not surveyed	N/A
March 1st	52	90.8	156	+72%
April 1st	51	101.7	166	+63%
May 1st	51	29.2	181	+520%
May 15th	25	2.4	Not surveyed	N/A

Notes:
1. At the Highland Valley snow survey station (Station No. 1C09A) near the Bethlehem TSF. Data prior to 1966 was not included as the station was moved to its current location in 1965.
2. Calculated based on available period on record.
3. SWE = snow water equivalent.
4. The March 1st survey was conducted on March 5, 2018. The April 1st survey was conducted on March 27, 2018. The May 1st survey was conducted on April 24, 2018.

4.3 Water Balance

THVCP manages and tracks the annual water balance for the Highland TSF. Table 4.3 is a summary of annual inflows and outflows, provided by THVCP. As a check, THVCP also calculated the difference in pond volume at the end of 2018 and 2017 using weekly pond elevations combined with a stage-

storage curve (Table 4.4). Both modelled and measured values indicate the Highland TSF was operated with a net gain for the 2018 calendar year; however, there is a 3.7 Mm^3 (approximate) difference between the two values. This discrepancy can be partially attributed to the challenges of capturing seasonal trends which are dependent on climatic conditions from previous months (e.g. highs and lows of temperature or precipitation in a year) when modelling over a calendar versus a hydrologic year. This effect can be exacerbated during "extreme" climatic periods such as the more severe, melt-induced freshet in 2018. THVCP considers the water balance model to be performing well.

Table 4.3 Annual Water Balance for Highland TSF

Item	2018 Volume (Mm^3)
Inflows	
Runoff[1]	14.14
Consolidation water	2.68
Water in tailings through H-H	104.65
Outflow from Jim Black Lake	0
Groundwater	0.64
Seepage Pond Collection	3.90
Spatsum	0.76
Total inflow:	*126.77*
Outflows	
Evaporation[2]	4.75
Seepage to Pukaist Creek	0.77
Entrainment	16.2
Construction Losses	7.55
Reclaim to Highland Mill	87.26
Total outflow:	*116.53*
Balance	
Water gained in impoundment over the calendar year (inflows - outflows)	10.24

Notes:
1. Adjusted precipitation values from Shula Flats weather station used in water balance model.
2. Evaporation at the Highland TSF was assumed to be 570 mm/year.

Table 4.4 Change in Pond Volume During 2018 for Highland TSF

	Volume (Mm^3)
Pond volume on Dec 21, 2017	13.0
Pond volume on Dec 13, 2018	19.5
Change in pond volume (2018 minus 2017)	+6.5

Note:
1. The discrepancy between modeled and observed volume changes (i.e. between Table 4.4 and 4.5) can be partially attributed to the challenges of modeling over the calendar year rather than the hydrological year.

4.4 Flood Management

The summary of flood management structures and the applicable design criteria and details for the seven facilities are given in Table 4.5 below, with the following points noted:

- The containment structures, except the Seepage Water Reclaim Pond and Seepage Pond 2, are able to safely route or store, with appropriate freeboard, storm events greater than or equal to the inflow design flood (IDF) required by the Code and recommended by CDA (2013).
- The Seepage Water Reclaim Pond relies on pumping to maintain water levels year-round, and in its current state, has insufficient capacity to store or route the IDF (KCB 2018b). If the IDF were to occur, water from the Seepage Water Reclaim Pond would flood the adjacent area, mainly Slimes Pond 1, potentially impacting THVCP operations but the downstream Laura Lake public road (~El. 1108 m) would prevent an offsite discharge. Design of a replacement pond for SWRP was completed in 2018, referred to as Seepage Pond 4, with increased flood storage capacity. Seepage Pond 4 was included in the 2018 permit amendment (KCB 2018d) and, pending approval, is scheduled to be constructed and commissioned by the end of 2021.
- In its current state, Seepage Pond 2 does not meet the minimum freeboard requirement (0.5 m) during the IDF (KCB 2018b). In 2016, KCB recommended THVCP commission works to lower the outlet pipe intake and re-grade the pipe to achieve a consistent downward grade from inlet to outlet. By maintaining the existing inlet invert elevation (1114.4 m), the system has capacity to route the IDF with sufficient freeboard provided the water level is not "perched" at the top of the existing bend (El. 1114.8 m), and the hydraulic capacity of the pipe is not compromised by the initial upward segment. This work was not completed in 2018 as planned due to Seepage Pond 2 being temporarily used as a slimes pond. THVCP advised that the pipe will be regraded as part of the work to reinstate Seepage Pond to the pre-2018 configuration.

Table 4.5 Inflow Design Flood Requirements for Highland Facility

Facility	Outfall Type	Consequence Classification	Inflow Design Flood	Design Event (Precipitation Depth, Design Flow/Volume)	IDF stored or routed?	Reference
L-L Dam	None	Extreme	PMF[1]	5-day PMF (423 mm [2], 49.4 Mm^3)	Stored	(KCB 2010)
H-H Dam	None	Very high	2/3 between 1000-year and PMF [1]	5-day PMF (423 mm [2], 49.4 Mm^3)	Stored	(KCB 2010)
Seepage Pond 2	Pipe	Significant	Between 100-year and 1000-year [3]	100-year 24-hour (75.5 mm [6], 1.9 m^3/s)	Routed [7]	(KCB 2018b)
Slimes Pond 2	Pipe	Significant [4]	Between 100-year and 1000-year [3]	100-year 24-hour (75.5 mm [6], 0.2 m^3/s)	Routed	(KCB 2018b)
Seepage Water Reclaim Pond	Pump	Significant	Between 100-year and 1000-year [3]	100-year 24-hour (75.5 mm [6], Note 7)	Routed (Pumped)	(KCB 2018b)
24 Mile Lake	None	Low	100-year [3]	24-hour PMF (210 mm [5], 2.2 Mm^3)	Stored	(AMEC 2014a)

Notes:
1. Per the Code (MEM 2016) for tailings dams.
2. Includes 367 mm of probable maximum precipitation (PMP) from the Environment Canada Highland Valley Lornex climate station (Station No. 1123469), and 56 mm of average annual snowmelt runoff estimated using average annual runoff from nearby streamflow stations.
3. Per the Code (MEM 2016) for water dams.
4. As assigned during the Dam Classification Workshop held in February 2015.
5. Based on data from the Environment Canada Highland Valley Lornex climate station (Station No. 1123469) (AMEC 2014b).
6. Based on Golder (2016).
7. Seepage Pond 2 does not have sufficient capacity to route the IDF in its current state. See discussion in Section 4.4 for recommendations to meet minimum freeboard requirements.

4.5 Freeboard

Where available, the minimum freeboard[5] measured during 2018 based on either the DSI site visit observations and/or the latest survey, are estimated in Table 4.6. The Code specifies that an evaluation of available freeboard in excess of the peak design flood level is required but defers to CDA (2013) for freeboard design standards. The following items are of note:

- There is no permanent pond at the H-H Dam and the crest is more than 10 m higher than L-L Dam; therefore, overtopping is not a credible failure mode. The minimum "buffer" for the H-H Dam reported in Table 4.6 refers to the vertical distance between the top of the tailings and the dam crest (KCB 2017b).
- No minimum freeboard assessment has been completed for 24 Mile Lake based on CDA (2013). However, the available freeboard is expected to exceed the minimum requirement because the available storage is far in excess of any IDF requirement (Section 5.3.3). If pond level in 24 Mile Lake were to rise above the perimeter the surrounding area would be flooded but there is no credible breach failure mode (KCB 2018b).

[5] The vertical distance between the pond level and the low point of the dam crest.

- Seepage Water Reclaim Pond is projected to be overtopped during the IDF and therefore does not meet minimum freeboard requirements (KCB 2018d). Seepage Pond 2 is projected to not meet minimum freeboard requirements. Refer to Section 4.4 for related discussion and recommendations.
- All other facilities meet freeboard requirements during the respective IDFs.

Table 4.6 Freeboard Summary for at Ponds with Regular Pond Level Monitoring

Dam	Required Minimum Freeboard[1] / Buffer[2]	Minimum Available Freeboard / Buffer[2] in 2018	Freeboard Surveyed/Visually Estimated
L-L Dam	2 m	9.4 m	Annual minimum from surveys
H-H Dam	1 m[2]	1.4 m[2]	Annual minimum from surveys, occurred near east abutment
Seepage Water Reclaim Pond	0.5 m	0.5 m	Annual minimum from surveys
24 Mile Lake	Note 3	>13 m	Annual minimum from surveys

Notes:
1. The vertical distance between the peak pond level during the IDF and the low point of the dam crest to accommodate wave runup and setup per CDA (2013).
2. "Buffer" measured between top of tailings surface and effective H-H Dam crest.
3. No minimum freeboard assessment completed; see discussion above for details.

5 REVIEW OF MONITORING RECORDS AND DOCUMENTS

5.1 Monitoring Plan

The Operation, Maintenance and Surveillance (OMS) manual, including the Emergency Preparedness and Response Plan (EPRP), was updated in 2018 (THVCP 2018) and will be issued by THVCP to EMPR. The 2018 update will supersede the versions submitted to EMPR in December 2016 and included the recommended items from the 2016 DSI (KCB 2017a).

- Review structure of report and include any data which is updated on an annual basis as an appendix which can easily be updated, rather than text in the body of the report (e.g. tailings production schedule, threshold levels, groundwater chemistry);
- Include a list of named individuals for each of the main roles of responsibility as an appendix to the OMS instead of in the main body of the text, to make it easier to update on a yearly basis;
- Include a plan(s) showing the location of all the facilities associated with the Highland TSF (seepage ponds, slimes ponds, inflows, outflows etc.);
- Review and update recommendations on minimum beach widths;
- Review and update the failure mode assessment; and
- Update definition of event-driven dam inspections.

The 2018 manual meets the intent of the Mining Association of Canada (MAC 2011) and CDA (2014) guidelines, is current and provides adequate coverage for existing conditions. The next update is planned for 2019 and should include discussion of Slimes Pond 4 as a contingency slimes storage facility and include in routine maintenance.

5.2 Inspections

The Highland TSF monitoring program includes the following visual inspections:

- Annual DSI (this report) – completed by the EoR to comply with Section 10.5.3 of the Code and submitted to EMPR.
- Routine – routine monitoring frequencies are summarized in Table 5.1. Summaries of dam inspection observations are provided to the EoR typically on a monthly basis and have been reviewed as part of this DSI. Inspections by THVCP staff have been completed at the prescribed frequencies during periods of the year when dams are accessible. KCB carried out quarterly dam inspections of the L-L Dam and H-H Dam as part of other routine site visits to support construction and other activities. The annual dam safety inspection in September constitutes one of the quarterly inspections:
  - Although no specific inspection is included in OMS manual for Slimes Pond 4, the area is visually checked as part of routine inspections of the nearby SWRP and Slimes Pond 1.

- Event-driven – completed by THVCP staff in response to unusual conditions and the threshold exceedances listed below (included in the 2018 OMS manual). EoR participation is determined on a case-by-case basis. Details of exceedances and/or unusual conditions, including trigger, response, and remediation / actions taken, are documented in a monitoring review memorandum (MRM) for record. Example triggers for event-driven inspections include:
  - rainfall event greater than the 10-year, 24-hour storm;
  - earthquake greater than magnitude 5 within 100 km of the site; and
  - non-compliance with specified quantitative indicators, as defined in the OMS, or at the discretion of the TSF Qualified Person or EoR, or EoR-AD, based on quantitative and qualitative indicators or other surveillance observations.

No event-driven inspections were triggered in 2018.

Table 5.1 Routine Visual Inspection Frequency

Dam	Inspection by THVCP	Inspection by KCB (EoR or Approved Designate)
L-L Dam	Weekly	Quarterly
H-H Dam	Weekly	Quarterly
24 Mile Lake	Quarterly	Quarterly
L-L Dam Seepage Pond 2	Monthly	Quarterly
L-L Dam Slimes Pond 1	Monthly	Quarterly
L-L Dam Slimes Pond 2	Monthly	Quarterly
L-L Dam Seepage Water Reclaim Pond	Monthly	Quarterly

5.3 Reservoir Levels / Tailings Buffer

5.3.1 Tailings Pond at L-L Dam

The Highland TSF pond elevation was measured weekly (minimum) during 2018 in compliance with the OMS manual. Figure 5.1 plots measured pond elevations over the past 5 years and the forecasted pond level for 2018. Figure 5.2 plots 2018 pond elevations and volumes, based on the most recent bathymetry survey. Observations related to tailings pond during 2018:

- During 2018, the pond elevation rose 3.8 m which is a significant increase over the annual rise during the previous 3 years which ranged from 0 m to 2.2 m. This is attributed to the additional pond volume at the end of 2018 relative to 2017 (6.5 Mm^3) as discussed in Section 4.3. THVCP water balance forecasts a 1.9 m rise in 2019 (to El. 1252.8 m) which is more consistent with recent trends.
  - THVCP report that the elevated pond volume in 2018 is due to increased precipitation compared to recent years and reduced reclaim required to support mill operations due to Lornex Pit dewatering project. These are not permanent changes to the water balance and

the pond volume is forecast to progressively reduce annually, including a 5.0 Mm^3 reduction by the end of 2019 to 14.5 Mm^3.

- During freshet the pond level rose approximately 5.2 m, which is in between the freshet rise observed during 2016 (3.8 m) and 2017 (6.3 m). 2018 pond levels continued to rise throughout the year, reaching the peak level (El. 1251.1 m) in November, a similar trend was observed in 2016 and 2014. Consistent with previous trends, pond level and volume fell starting in December which has continued into 2019, albeit at a reduced rate to previous years due to additional water being supplied by the Lornex Pit dewatering project.

Figure 5.1 Highland TSF Tailings Pond Elevations: 2014 to 2018

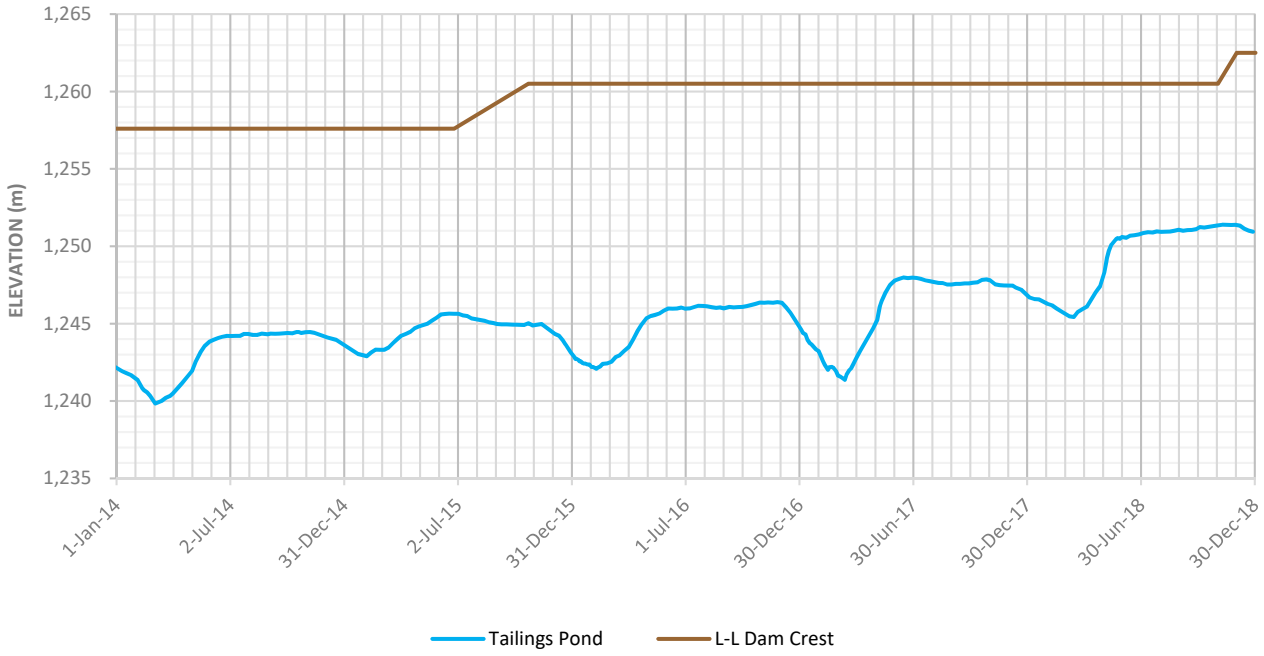
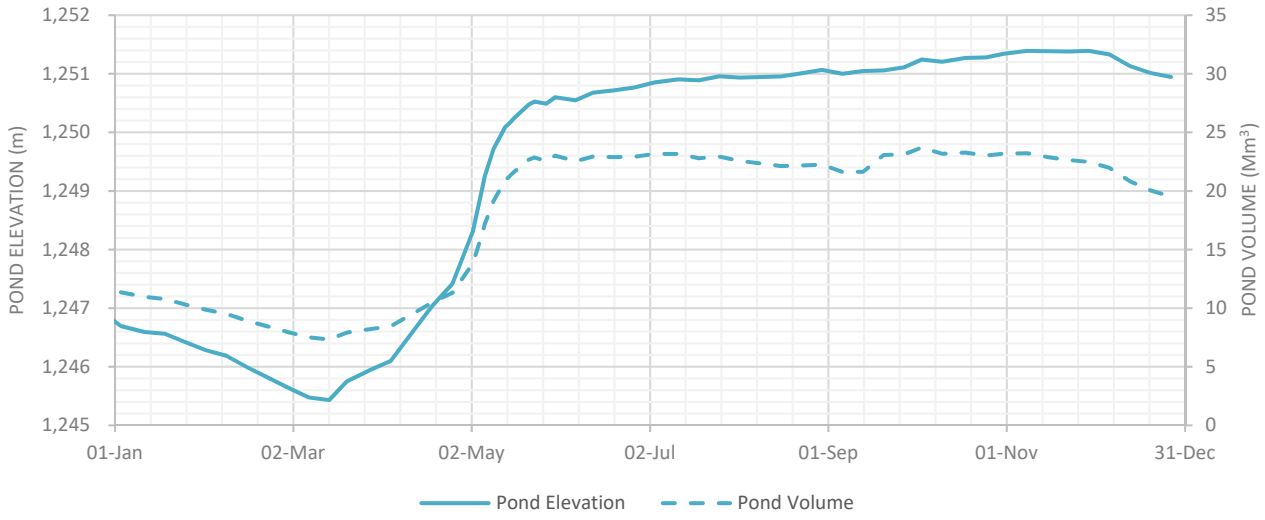


Figure 5.2 2018 Highland TSF Tailings Pond Elevations and Estimated Pond Volumes



5.3.2 Tailings Beach at H-H Dam

There is no permanent free water pond against H-H Dam during normal operating conditions and hence, there are no specific freeboard reporting requirements defined in the M-11 and PE-376 permits. However, the 2018 OMS update specifies that the tailings beach at the H-H Dam should be maintained a minimum of 1 m below the effective dam crest to prevent erosion and overrunning of tailings onto the dam crest during active tailings deposition. This “1 m buffer zone” applies to a situation that can be controlled by operational changes (e.g. relocating discharge points) and is not the same as conventional freeboard requirements associated with a free water pond for protection against wave run-up and flood surcharge. The “effective dam crest,” as defined in KCB (2017b), is measured to the top of confinement for tailings, whether that is provided by the top of the Glacial Till core, rockfill or any berms that are along the upstream edge of the crest.

In 2018, the tailings beach was surveyed weekly, per the OMS manual. Tailings beach elevation at various stations along the H-H Dam crest between 2015 and 2018 are shown on Figure 5.3. Tailings buffer between the top of the tailings surface and the effective dam crest through 2018 along the dam crest are shown on Figure 5.4.

Figure 5.3 H-H Dam Tailings Beach Elevations Along Crest: 2015 to 2018

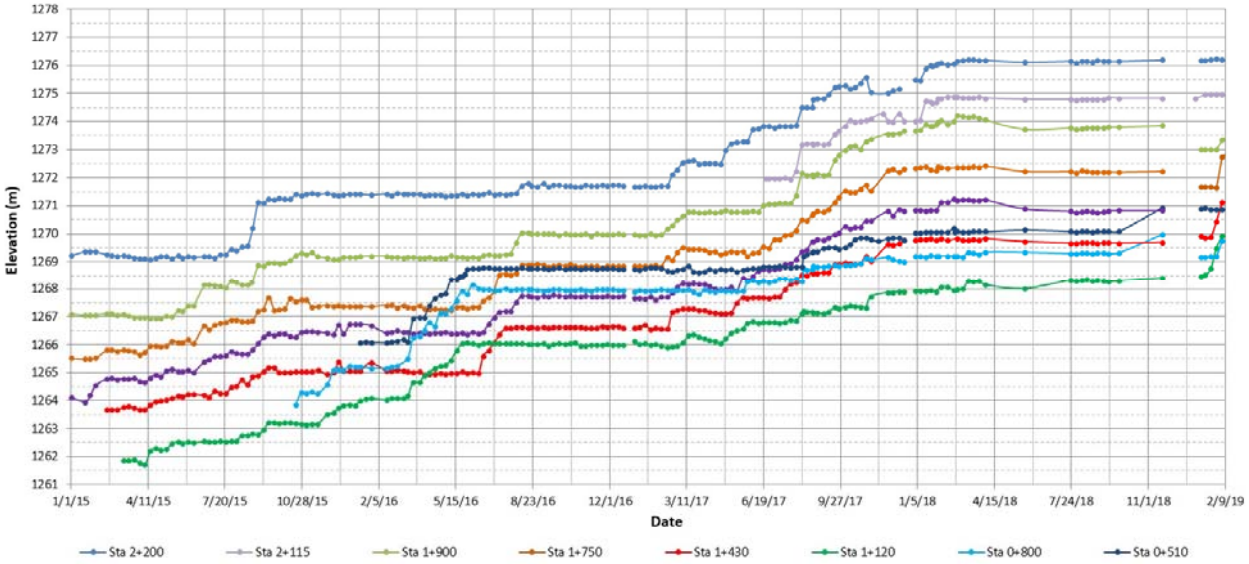
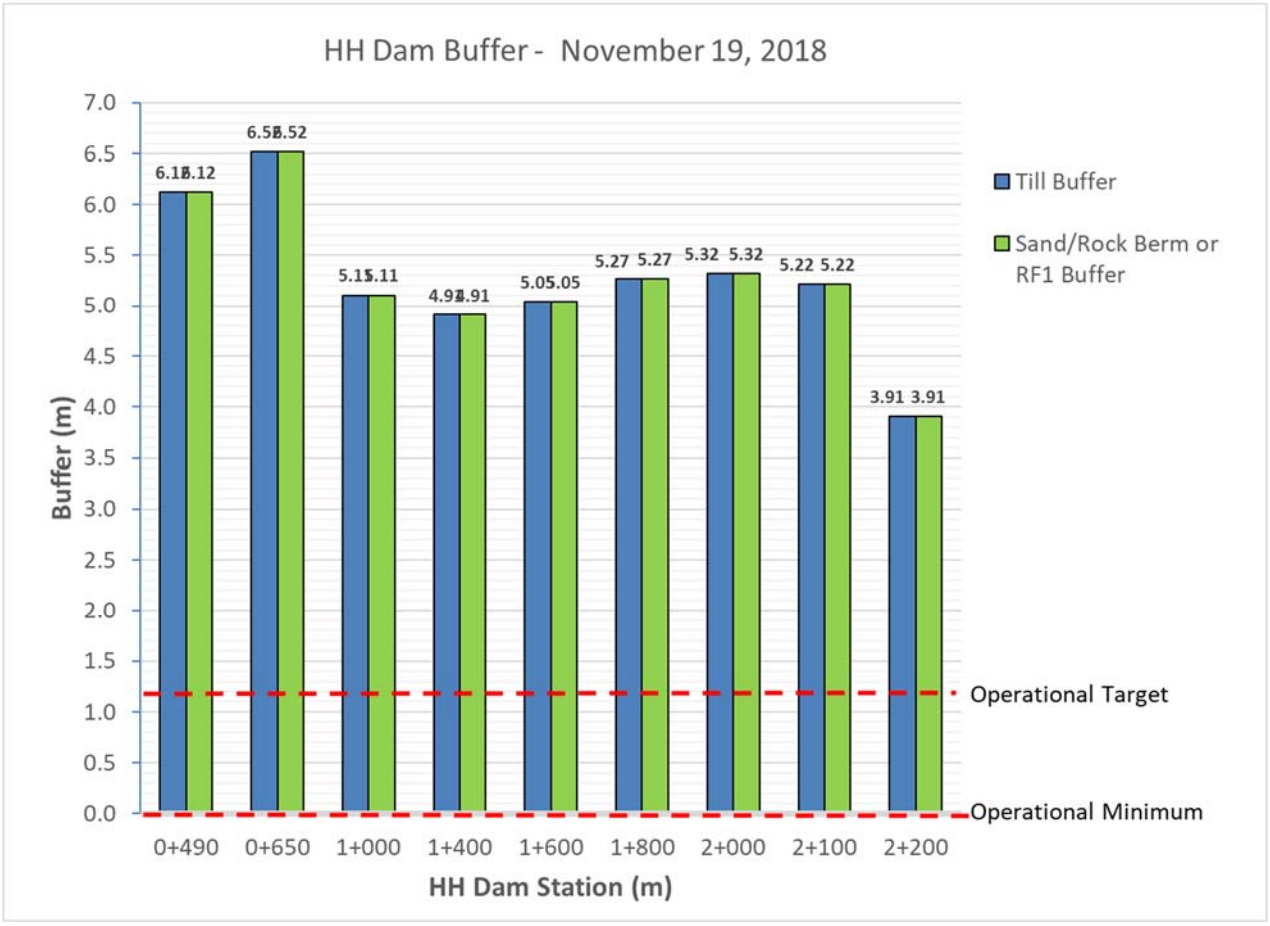


Figure 5.4 2018 H-H Dam Tailings Buffer Along Crest After H-H Dam Crest Raise



5.3.3 24 Mile Lake

24 Mile Lake pond elevation was measured weekly (minimum) during 2018 in compliance with the OMS manual. Observations related to the pond during 2018:

- During 2018, the pond elevation rose 1.7 m to El. 1199.6 m, peak pond level during 2018 was El. 1202.3 m.
- Although no formal dam or embankment exists, the lowest point in the perimeter containment of 24 Mile Lake is approximately El. 1220 m (AMEC 2014a), providing more than 17 m of freeboard throughout 2018. If the inflow from a 24-hour duration PMF were added to the 2018 peak pond level, there would be more than 13 m of freeboard.

5.3.4 L-L Dam Seepage Collection and Slimes Ponds

The Seepage Water Reclaim Pond is routinely surveyed to track pond levels. In 2018, the pond level varied up to 3 m with 2 spikes, related to freshet and construction inflows. The minimum freeboard measured was 0.5 m.

The remaining seepage collection and slimes ponds are visually inspected monthly at which time the dam inspector estimates the available freeboard.

KCB recommends expanding the routine pond level survey activities to include Seepage Pond 2, Slimes Pond 2, Slimes Pond 4 and Slimes Pond 3 (when its construction is completed) on a monthly basis, per the 2018 OMS manual.

5.4 Dam Instrumentation Summary

Starting in 2015 THVCP have invested significant resources into improving the instrumentation monitoring at both the L-L Dam and H-H Dam. This continued into 2018 with: installation of additional instrumentation; further development of the remote monitoring system; applying inclinometer reading corrections; implementation of a revised Trigger-Action-Response-Plan (TARP); and management, processing, summarizing and reporting of instrumentation data. The instrumentation data set that must be managed is significant and includes more than 310 instruments.

THVCP and KCB dedicated significant effort to improve instrumentation processes in 2018. There are additional improvements planned for 2019. This effort has improved THVCP's and KCB's ability to monitor instrumentation for compliance with design assumptions, identify outliers or potential readings of concern as well as better defined roles and responsibilities for routine and non-routine (e.g. threshold exceedances) instrumentation reviews. The instrumentation summary plots in Appendices IV to VIII are tools used as part of routine monitoring.

Some 2018 instrument readings were not collected at the frequency prescribed under the OMS manual as a result of multiple factors such as: inability to access panel during placement; winter access restrictions; and resource restrictions. However, due to the redundancies designed into the instrumentation program and the processes in place for prioritizing the more critical instruments of key dam segments, KCB do not consider these as a major non-compliance that compromised the

effectiveness of the dam safety management program in any way. Most of these instances were inclinometer readings. Given the increase in the number of installations over the past several years, and the great depths associated with most of the installations, optimization of the reading frequency and prioritization of the instruments were identified as an important activity in 2018. This work is ongoing, including the use of in-place inclinometers (IPIs) in critical dam areas. These actions and the other process improvements have led to fewer instances where an instrument was not measured at the prescribed frequency.

Improvements were also made during 2018 to ensure the quality of the inclinometer data for interpretation, including addressing the following issues:

- Inclinometer plots and interpreted movement rates are sensitive to the measurement reel used to collect the readings which is sometimes changed between readings, for example, when the normal reel is offsite for routine calibration checks. If the reel is changed, larger incremental movements can be inferred than have occurred. In 2018, THVCP established improved tracking of the inclinometer reels so that corrections for reel changes can be readily made. For this reporting period, the summary plots in Appendix IV only show select readings where KCB and THVCP have reviewed and corrected for change in reels.
- Inclinometer plots and interpreted movement rates are also impacted by the rotation of the inclinometer casings. In 2018, THVCP initiated a concerted effort to apply rotation corrections to the inclinometer readings, which has removed some of the apparent “swaying” characteristics of two inclinometer cumulative movement plots:
  - Going forward, THVCP plan to filter out the above-mentioned influences that are instrument related. KCB are preparing plots which will show the cumulative displacement over the available measurement period in critical foundation units controlling dam stability (i.e. glaciolacustrine and mudstone shear planes). These are still in development.

Instrumentation and monitoring points at the L-L Dam include: piezometers to monitor pore pressure; inclinometers to monitor horizontal displacement in the fill and foundation; and seepage weirs to monitor flow rates. The number and type of instruments installed in the L-L Dam at the end of 2018 are summarized in Table 5.2. During 2018 22 additional piezometers were installed. The number of instruments at the L-L Dam is driven by the geologic complexity of the foundation and the importance of having redundancy in key areas.

Section 5.5 summarizes the instrumentation response measured at the L-L Dam during 2018 and a comparison with established historic trends and design assumptions. In some cases, measurements from early 2019 are referenced if they indicate or support a key trend not observed based on 2018 readings alone.

Table 5.2 Summary of Functional Instrumentation Installed at L-L Dam

Instrument	Type	Reading [1]	No.	Total
Piezometers	Standpipe	Manual	100	246
	Transducer (Converted Standpipe)	Automated	40	
	Vibrating Wire	Automated	106	
Inclinometers	Down-hole Casing	Manual	29	32
	In-Place Inclinometer (IPI) [2]	Automated	2	
	Shape Accelerometer Array (SAA) [3]	Automated	1	
Seepage Weir	-	Manual	3	3

Notes:
1. Automated readings are transmitted through the remote monitoring system to increase data capture and summarize instrumentation.
2. IPIs are installed in down-hole casing inclinometers over a discrete elevation range which is defined by the EoR to target critical units.
3. A 100 m SAA array is installed in the lower portion of a 107 m drill hole (LLSAA12-1).

Instrumentation and monitoring points at the H-H Dam include: piezometers to monitor pore pressure; inclinometers to monitor horizontal displacement in the fill and foundation; and Sondex system to monitor settlement. The number and type of instruments installed in the H-H Dam at the end of 2018 are summarized in Table 5.3. During 2018 1 Sondex settlement system was damaged during construction and had to be decommissioned. No new instrumentation was installed at H-H Dam during 2018. The number of instruments at the H-H Dam is significantly less than at the L-L Dam primarily due to the fact that there is no pond upstream, the toe is supported by a waste dump, and the geologic and hydrogeologic regimes are less complex.

Section 5.6 summarizes the instrumentation response measured at the H-H Dam in 2018 and a comparison with established historic trends and design assumptions.

Table 5.3 Summary of Functional Instrumentation Installed at H-H Dam

Instrument	Type	Reading [1]	No.	Total
Piezometers	Standpipe	Manual	10	35
	Transducer (Converted Standpipe)	Automated	-	
	Vibrating Wire	Automated	30	
Inclinometers	Down-hole Casing	Manual	7	8
	Shape Accelerometer Array (SAA) [2]	Automated	1	
Settlement	Sondex [3]	Manual	5	5

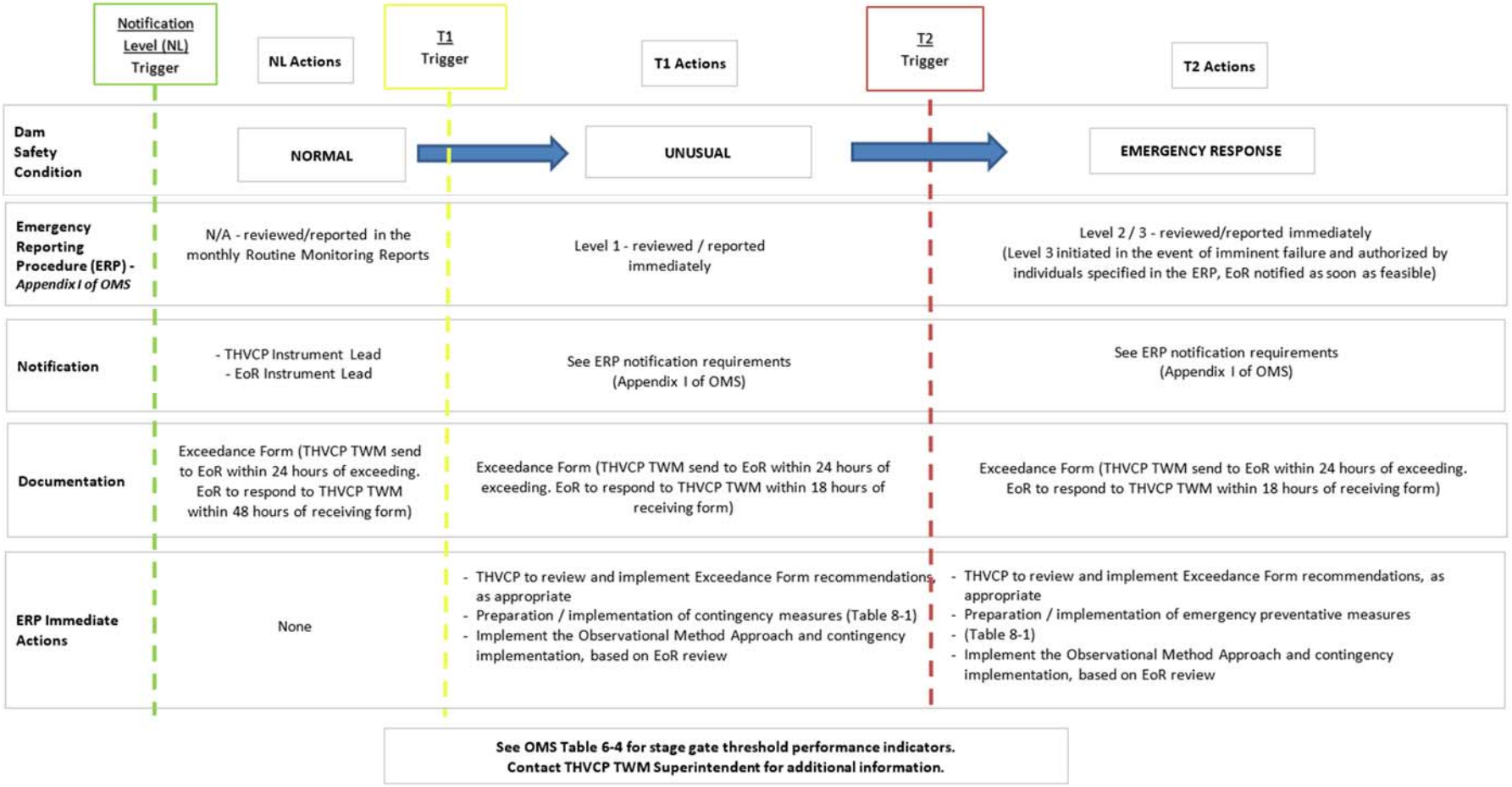
Notes:
1. Automated readings are transmitted through the remote monitoring system to increase data capture and summarize instrumentation.
2. A 90 m SAA array is installed in the lower portion of a 103 m drill hole (HHSAA12-1).
3. Sondex settlement monitoring systems were installed at the HH17 series inclinometers. HH17-16A was damaged and could not be recovered during 2018 construction.

The TARP which came into effect August 2018, more clearly defines the appropriate response to performance indicators (e.g. instrumentation measurements) and communicates this to both THVCP and KCB teams. Figure 5.5 is the most recent TARP for the Highland TSF, which includes some modifications to the version currently included in the OMS manual (THVCP 2018). THVCP have adopted this most recent version and it will be included in 2019 OMS manual update.

The TARP includes three levels of potential response, each reflective of a general condition relating to design and emergency preparedness, and response level as well as communication protocols and other actions to be taken. Threshold values are defined annually by the EoR, in consultation with THVCP, and a summary included in the OMS manual. The following definitions are updated definitions which will be included in the 2019 OMS manual:

- Notification Level (NL):
  - The dam is performing according to design assumptions and is not a dam safety concern;
  - The main objective of the NL trigger is to identify a measured change from historic or expected behaviour that does not compromise dam safety but warrants review by THVCP and the EoR (or EoR-AD) to QA the reliability of the readings and/or to understand the likely cause of that change.
- T1 Level:
  - The measured behaviour is not consistent with design assumptions / predictions but there is no immediate dam safety concern.
  - With respect to instrumentation, the main objective of the T1 trigger is to identify a pattern of behaviour which may lead to a condition whereby the limit equilibrium static factor of safety could be temporarily reduced to below the design requirement of 1.5 but is still well above unity. Under this condition, the protocol is for THVCP and the EoR (or EoR-AD) to review the data and determine whether appropriate action is necessary to increase the factor of safety to comply with design criteria, such as construction of the contingency berm for the VBB. T1 threshold values are generally based on the expected behaviour of the geological unit(s) that governs the stability of a particular segment of the dam.
- T2 Level:
  - The measured behaviour is more adverse than design assumptions / predictions and there is a potential dam safety concern.
  - With respect to instrumentation, the main objective of the T2 trigger is to identify a pattern of behaviour that is indicative of a potential developing condition which could ultimately lead to a dam failure scenario. T2 threshold values are generally based on the expected behaviour of the geological unit(s) that governs the stability of a particular segment of the dam and are guided by hypothetical simulations of potential failure scenarios using the stress-deformation model (FLAC).
  - T2 triggers are assessed in terms of a macro response (i.e. a number of inclinometers and piezometers indicating overall behaviour) rather than a local response that is not replicated in adjacent instruments.

Figure 5.5 Trigger-Action-Response-Plan for Highland TSF



2018 threshold values for instruments installed after 2015 were based on a reduced measurement period and were set relatively conservatively at the outset. In some cases, the threshold value for piezometers did not consider the normal seasonal fluctuation (i.e. freshet) or other trends not related to dam safety (i.e. temporary effects of hydraulic cell construction). This resulted in a greater number of NL exceedances than otherwise envisioned. The thresholds for those instruments were modified or suspended until there was sufficient data available to assign more appropriate values. The need to modify or suspend thresholds is expected to reduce in 2019 as all thresholds have been reviewed and updated based on data up to and including December 2018.

T1 and T2 instrument threshold exceedances measured during 2018 are discussed in Section 5.5 and 5.6. Exceedances which were subsequently found, after close review, to be associated with inappropriately established threshold values, are not discussed. NL exceedances are also excluded in the discussion.

5.5 L-L Dam 2018 Measured Instrumentation Response Summary

5.5.1 South Dam: Sta. 0+800 (South Abutment) to Sta. 1+500

South Dam foundation mainly comprises competent glacial till overlying granodiorite bedrock. Stability is primarily controlled by the strength of Glacial Till.

T1 or T2 actions, refer to Figure 5.5, were not triggered during 2018 at the South Dam. Instrumentation summary plots can be found in Appendix IV (inclinometers) and Appendix V (piezometers). Instrumentation readings are plotted on a typical cross section through the South Dam at Sta. 1+200, refer to Appendix VI.

Piezometers

Piezometers installed near Sta. 1+050 (LL-VWP17-03A, -03B, -03C, P02-2, LL-VWP02-03 and LL-VWP02-01) rose 1.5 m to 5 m between April and August which corresponds to the period of downstream hydraulic sand placement in the area. Five of the piezometers were installed in the foundation (Glacial Till and Granodiorite bedrock) while one was installed in glacial till fill which was used to construct the initial raise in the area. Hydraulic placement cells and the glacial till fill were separated only by a layer of compacted sand fill. This close hydraulic connection was identified as the trigger for the response. Piezometric levels started to dissipate after hydraulic placement was completed which supports the observation this was a construction related response. The dissipation rate has leveled off towards the end of 2018 and are currently typically 2 m higher than at the start of 2018.

The piezometric levels measured by the LL-VWP17-03 set of instruments exceeded the T1 instrument threshold value but did not trigger T1 actions because the piezometric levels, although elevated, were below the level required to lower the factor of safety to below criterion.

Two of the standpipe piezometers at the South Dam (P13-3 and P86-2001) measured significant drain down in piezometric level during 2018, ranging from 7.5 m to 15 m. However, both are located downstream of the dam toe and the response is not observed in piezometers closer to the dam.

Inclinometers

There are 2 inclinometers installed at the South Dam: I10-8 (~Sta. 1+200); and I10-1 (~Sta. 1+500). Increased movement rate was observed in the cycloned sand dam fill during construction between April and August. Movement was distributed over a thick zone with no indication of discrete shear planes that may be of concern. Movement rates have all reduced since placement was completed and the peak movement rates measured in 2018 were below threshold levels. This increased movement is an expected response to the additional loading and increase seepage from hydraulic placement.

There is an indication of a potential discrete movement zone forming near the base of I10-8 (~El. 1194 m). However, this apparent movement is measured in the foundation granodiorite bedrock and is in the upstream direction. This is an example of a feature which should be reviewed to identify cause of apparent movement and if not dam safety related, filtered out from the inclinometer measurement plots.

Prior to 2018 construction, no significant movements had been measured at these instruments.

5.5.2 Valley Buttress Berm: Sta. 1+500 to Sta. 2+100

The VBB foundation mainly comprises thick (90 m) sequence of glacial deposits with continuous layers of glaciolacustrine deposits. Stability is primarily controlled by the Lower-Glaciolacustrine unit. The Upper-Glaciolacustrine unit, at the base of the Lacustrine deposit, has been removed under the downstream shell during foundation preparation.

T1 or T2 actions, refer to Figure 5.5, were not triggered during 2018 at the VBB. Instrumentation summary plots can be found in Appendix IV (inclinometers) and Appendix V (piezometers). Instrumentation readings are plotted on a typical cross section through the VBBE at Sta. 1+850, refer to Appendix VI.

Piezometers

Instrumentation coverage in the Lower-Glaciolacustrine unit and the sand and gravel drainage blanket at the VBB was increased in 2017 more than in any other zones in the L-L Dam. This was done to support use of the Observational Method (Peck 1969) to manage dam safety risks as described in KCB (2018d). 2018 was the first complete calendar year of data available for interpretation with a baseline established between January and March before construction commenced in the area during April. This has provided further insights into the dam response to changing loading which can be used to compare against expected behaviour based on design.

The piezometric regime at the VBB can be grouped into 3 different zones: Sand and Gravel Drainage Blanket; Lower-Glaciolacustrine; and Lower Sand and Gravel. Inferred piezometric surfaces for each of these zones are shown on the instrumentation section in Appendix VI. Piezometric conditions in the Glacial Till represent a transition zone between the dam fill and Lower-Glaciolacustrine zones as well as demonstrate a downward gradient.

Piezometric levels within the Lower Sand and Gravel zone were consistent throughout the year with very little to no rise or fluctuation in 2018. This is consistent with historic performance as no response to rising pond level or construction activity has been recorded in this zone by the current or defunct instruments throughout Highland TSF operations.

Piezometric levels within the Lower-Glaciolacustrine zone rose in the dam footprint, or nearby, of the 2018 hydraulic cycloned sand placement (i.e. upstream of LL-VWP17-09B). The typical rise varied between 2.5 m and 5.0 m and occurred during the period of fill placement. The largest responses were measured at piezometers beneath the upper slope (e.g. LL-VWP17-01B and LL-VWP17-06B) which was the expected response as fill was placed directly over the Lower-Glaciolacustrine in this area and the overconsolidation ratio would likely be lowest or potentially normally consolidated (KCB 2018d). During construction, the piezometric response was tracked as percentage of the vertical fill load. Values remained low throughout placement, 11% or less, excluding an outlier spike up to 25% at LL-VWP17-02B. This spike was not observed at nearby instruments and dissipated quickly, below 10% within 1 week. In any event, the measured responses were well below the T1 threshold value, which was specified as 50% of the vertical fill load. There has been limited dissipation (up to ~0.7 m) of the construction induced piezometric pressures since placement was completed. The sand and gravel drainage blanket at the VBB is a non-critical unit in terms of stability and the dam is not sensitive to even large increases in piezometric pressures in this layer. As such prior to 2018, there were only two manually read standpipe piezometers installed in the layer (P12-5 and P13-9). The sand and gravel drainage blanket at the VBB is the low point of the dam and one of the central collection and seepage points in the dam fill. Piezometric levels in the area were given an increased focus to better define the response to construction, seasonal change and drain down behaviour. This information will support the ongoing design review, hydrogeology and closure work. In 2017, two VWP piezometers were installed in the layer and one of the standpipes was converted to automated readings with a transducer (LL-VWP13-09).

Prior to 2018 construction, it had been 32 months since hydraulic cycloned sand had been placed on the downstream shell (August 2015). Typically, hydraulic cycloned sand is placed annually with much shorter drainage periods between construction periods. Therefore, the piezometric levels measured prior to the start of 2018 are likely representative of a fully, or close to, drained down condition.

Downstream of the starter dam, the Lacustrine Unit was excavated from the dam foundation. The excavation was backfilled with sand and gravel fill which is in contact with the lacustrine excavation slope near the toe of the original starter dam, as shown on the instrumentation section in Appendix VI. During 2018, the measured response at piezometers installed in the Lacustrine Unit (e.g. LL-VWP17-01C and LL-VWP17-06D) matched the response observed from the sand and gravel drainage blanket piezometers. The response observed in the sand and gravel drainage blanket during 2018 is summarized as follows:

- Prior to construction, January through early April, piezometric levels were static. Water levels at this time were below or near to the top of the sand and gravel drainage blanket.
- Shortly following the start of construction, in late April and early May, the piezometric levels started to rise at all instruments in the sand and gravel drainage blanket and lacustrine.

- The instruments continued to rise throughout 2018, typically between 4 m and 5 m. The rate of rise has remained relatively constant through the remainder of 2018 and into 2019. Even after fill placement shifted from the VBB to the North Dam in August and even 3 months after all downstream hydraulic cycloned sand fill placement was suspended.
- In addition to placement of hydraulic cycloned sand fill, Seepage Pond 1 was backfilled with sand and gravel which extended the seepage face further downstream. The water level in Slimes Pond 1 is also elevated relative to the start of 2018. Both of these items could slow drain down relative to prior years. However, the drain down pattern and timeline has not been previously measured for comparison.
- As mentioned, the sand and gravel drainage layer at the VBB is the low point of the dam and primary collection area for seepage through the fill. This ongoing, steady rise is interpreted as the ongoing drainage of seepage from the hydraulic placement moving through the sand and gravel drainage blanket.
- The stability of the VBB is governed by slip surfaces in the Lower-Glaciolacustrine Unit. In order for the critical surface to extend up into the Sand and Gravel drainage blanket, the piezometer level would need to rise to the extent that nearly the entire VBB bench fill is fully saturated. The current elevated piezometric levels do not represent a dam safety concern.
- Notwithstanding the above stability consideration, THVCP and KCB are taking a proactive approach to increase drainage capacity, long-term and short-term drain down by constructing a major drain along the toe of the VBB.

Inclinometers

There are 12 inclinometers installed at the VBB to monitor deformation within the Lower-Glaciolacustrine Unit, as well as other foundation units, to support implementation of the Observational Method as described in KCB (2018d). For redundancy, the instruments are roughly split along two parallel instrumentation lines perpendicular to the crest. General IDs were assigned to identify the location along the downstream slope each inclinometer is installed (Figure 5.6) The inclinometers and their location ID are summarized in Table 5.4. T1 threshold values are assigned for inclinometers in the upper part of the downstream slope. T2 threshold values are assigned for inclinometers installed through the lower half of the slope and at the toe.

Figure 5.6 VBB Inclinometer Location ID

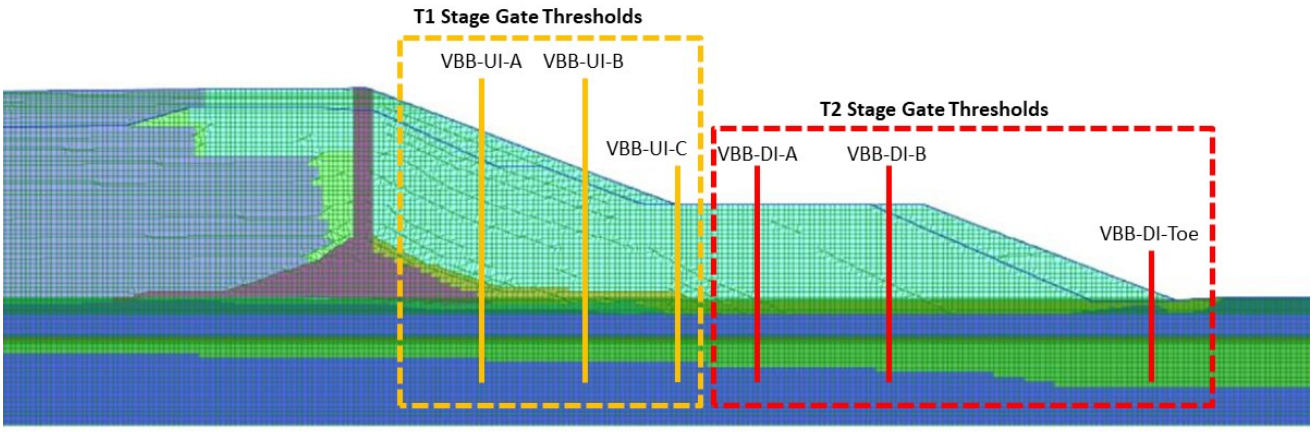


Table 5.4 VBB Inclinometers and Assigned Location ID

Location ID	Inclinometers North of ~Sta. 2+000	Inclinometers ~Sta. 1+910	Inclinometers ~Sta. 1+850
VBB-UI-A	I17-01	-	I17-06
VBB-UI-B	I10-6	LLSAA12-1	I10-7
VBB-UI-C	-	-	I17-02
VBB-DI-A	I17-19	-	I17-09
VBB-DI-B	I17-10	-	I15-24
VBB-DI-Toe	I17-11	-	I15-27

In 2018, none of the measured movement exceeded the current T1 or T2 threshold values. Some of the inclinometers had issues related to instrumentation data that need to be resolved, such as variability in reel, spiral corrections and casing compression zones. Resolution of these issues has been completed at some of instruments and the remaining will be resolved in 2019 (e.g. I17-10 and I17-11). As mentioned previously, due to the density of instruments in the VBB and redundancy in the monitoring, KCB does not consider short-term gaps in the data as a major non-compliance that compromises the effectiveness of the dam safety management program in any way. The work done during 2017 and 2018 has established the baseline for the new instruments and processes which will be carried forward.

A general summary of the behaviour based on slope location are summarized below:

- Upper Slope Inclinometers:
  - VBB-UI-A – these were the only inclinometers that were within the fill placement area at the VBB. As discussed, the greatest piezometric response in the Lower-Glaciolacustrine Unit were measured at these locations. An increase in movement rate in response to the load can be seen in the data; however, the overall rates were low in both the Lower-Glaciolacustrine Unit (~0.5 mm/month) and the Lacustrine Unit (~1 mm/month).

- As mentioned previously, the Lacustrine Unit was excavated from the L-L Dam footprint downstream of the starter dam and is therefore, not continuous to the toe. Any movement in the Lacustrine Unit is constrained to the unit itself and has a negligible influence on the stability of the overall dam. The 2018 movement rate is consistent with rates measured during 2015 construction which placed fill at the VBB just downslope of the 2018 placement area.

- VBB-UI-B:
  - Variability in the readings are apparent in the measurements at I10-6 and I10-7, during the period prior to construction loading. THVCP were able to resolve this reading variability and improve reliability during construction at both instruments.
  - These inclinometers were approximately 75 m downstream of the 2018 fill placement zone. The highest movement rate measured in the Lower-Glaciolacustrine Unit during 2018 was at I10-7 which reached an average rate of ~3 mm/month between mid-April and mid June (during loading). This rate approached the T1 threshold value. However, KCB recommended that T1 actions were not warranted because the movement rate was not seen at the adjacent I10-6 (~0.5 mm/month) or other downstream instruments. The movement rate dissipated quickly to ~0.8 mm/month starting mid-June and rates continued to dissipate towards the end of the year similar to other instruments.
  - The movement rates measured in the Lacustrine unit were similar to those measured upstream (~0.8 mm/month
  - Both I10-6 and I10-7 were installed using air-rotary drilling and the Lower-Glaciolacustrine layer was not logged at these locations. However, the layer was assumed continuous in this area for design. Based on the 2018 response to loading, THVCP inferred the extent of Lower-Glaciolacustrine layer which agreed with the elevation inferred by KCB based on nearby drill holes. This zone has been identified and is included in routine monitoring but THVCP has not yet updated the geology on the inclinometer summary plot and should do so in 2019.
- VBB-UI-C – There was variability in the readings at I17-2 which was improved for the start of construction by the additional controls THVCP implemented. After this time the readings indicate very low movements within the Lower-Glaciolacustrine during 2018 (~1 mm). Reading from November and December appear as outliers and not related to dam movement.

- Lower Slope Inclinometers:
  - VBB-DI-A – Measurement profiles for both I17-09 and I17-19 show compression zones and very limited incremental movements in the Lower-Glaciolacustrine unit. A peak rate of 0.8 mm/month was measured at I17-09 between late-April and mid-June which later attenuated to a negligible rate after August (<0.1 mm/month). Negligible movements were measured at I17-19.

- VBB-DI-B:
  - The 2018 thresholds in the downstream instruments were set intentionally conservative, but by doing so, it was recognized that even small instrument errors can create a “false-positive” exceedance. To manage this risk, an IPI was installed at I15-24 which extended above and below the Lower-Glaciolacustrine unit to improve reliability. The IPI was not removed throughout 2018 and very small movements were measured with no discernable response to construction loading. Over 2018, the average movement rate was ~0.04 mm/month (i.e. ~0.5 mm over 12 months). The IPI measurements indicate a compression curve near the base of the measurement zone, which was not considered in the movement rate calculation.
  - I17-10 does not have an IPI and is measured over the full casing length to identify potential movements in other units. There are indications of compression curves through the portion of the casing in the foundation. Ignoring consideration of the compression zone(s), the incremental movement over the Lower-Glaciolacustrine is negligible.
- VBB-DI-Toe – No significant movements were measured in the Lower-Glaciolacustrine at the downstream toe of the VBB. Both I15-27 and I17-11 indicates >1 mm total movement during 2018. As discussed for I15-24, an IPI was installed across the Lower-Glaciolacustrine at I15-27 to limit the potential influence of excessive “noise” in the instrumentation readings.

Observed behaviour during 2018 have been adopted into the ongoing design review and have been incorporated into the 2019 threshold values with consideration for 2019 fill placement areas.

5.5.3 Valley Buttress Berm Extension: Sta. 2+100 to Sta. 2+400

The VBBE foundation is a transition between the VBB and NBB as the thickness of glacial deposits reduces to the north, discontinuous layers of glaciolacustrine deposits are present and govern stability.

T1 or T2 actions, refer to Figure 5.5, were not triggered during 2018 at the VBBE. Instrumentation summary plots can be found in Appendix IV (inclinometers) and Appendix V (piezometers). Instrumentation readings are plotted on a typical cross section through the VBBE at Sta. 2+250, refer to Appendix VI.

Piezometers

Piezometers in the overburden and foundation units remained steady throughout 2018. The instrumentation cross section in Appendix VI shows that the glacial deposits and dam fill in the area have low piezometric heads and indicate potential perched water tables in some areas. Larger piezometric heads are measured in the bedrock but are more than 40 m below the base of dam fill.

A temporary on-dam slimes storage cell was established and operated on the lower bench of the VBBE between mid-June through July. A cluster of 4 piezometers instruments installed in different

foundation units, LL-VWP17-07(A to D), is directly below the centre of the on-dam slimes cell. No piezometric response was measured at any of the locations which is consistent with the field observation that the cell sealed up and became water retaining fairly quickly.

Inclinometers

There are four inclinometers installed in the VBBE dam segment: I17-08 (~Sta. 2+100, dam toe); I17-07 (~Sta. 2+150, lower bench); I10-11 (~Sta. 2+200, mid slope); and I10-5 (~Sta. 2+350, mid slope). There are no movement zones at or near threshold values which can be traced between instruments. General observations from each instrument are as follows (listed in order starting with most upstream instrument and continuing downstream):

- I10-5 – no shear zones are present and very low movement rates are measured across the units (< 0.3 mm/month) with no significant response to construction activity observed. Readings in Appendix IV are plotted over two time periods May 2017 to October 2017 and May 2018 to January 2019 to filter out systematic errors in the data. The complete data set does not indicate any significant change in movement between these two periods, which is consistent with the fact that there was no construction loading in the area over the same period.
- I10-11 – there are compression zones in the section of casing through the Lower Sand and Gravel which distort the cumulative displacement plots; however, these are filtered out on the incremental plot which does not show any signs of any discrete movement zones.
- I17-07 – the cumulative displacement plot shows a large upstream movement (~200 mm over 22 m vertical measurement zone) in the cycloned sand dam fill between the March 2018 and April 2018 readings. This timeframe is prior to the start of construction. The incremental displacement plot indicates movement in this zone was restricted to these two readings which indicates it was related to a measurement error rather than actual dam movements. THVCP have established a new baseline reading for the instrument going forward to resolve this issue. There are compression zones in the glacial overburden which also distort the cumulative displacement plot. The incremental displacement plot indicates an apparent movement zone around the glaciolacustrine layer within the glaciofluvial deposit. However, this is an upstream movement (A-axis, negative) and the characteristics of the casing suggest an “extrusion” type mechanism, which is not likely. Therefore, the readings at that depth are instrument related or caused by casing compression, rather than an actual induced shear zone.
- I17-08 – the incremental displacement plot shows two compression zones in the Lower Sand and Gravel which were first measured between the September 2018 and November 2018 readings. On the A-axis of the cumulative displacement plot, measurements indicate that the direction of movement was upstream between the December 2018 and January 2019 readings. Excluding the compression zones, there are no zones of discrete movement.

One of THVCP’s initiatives for 2019 is to filter out instrumentation or measurement errors from the data set so it does not hinder interpretation.

5.5.4 North Buttress Berm: Sta. 2+400 to Sta. 2+800

NBB foundation mainly comprises mixed bedrock at surface or shallow depth, between volcanic and sedimentary units of the Kamloops Group, sedimentary bedrock includes mudstone sequences. Stability is primarily controlled by weak bedding planes in the high-plasticity mudstone sequences.

T1 or T2 actions, refer to Figure 5.5, were not triggered during 2018 at the NBB. Instrumentation summary plots can be found in Appendix IV (inclinometers) and Appendix V (piezometers). Instrumentation readings are plotted on a typical cross section through the NBB at Sta. 2+564, refer to Appendix VI.

Piezometers

Piezometric levels in the bedrock foundation are variable, even in the same units indicating potential for perched water tables or preferential flow paths. The piezometers in the glacial overburden are more consistent. Some of the bedrock piezometers show a discrete response to freshet, particularly those installed in the mid bench (e.g. LL-VWP96-02B), which are influenced by ponding of surface water that occurred in the low point the north side of the NBB during freshet. This ponding and associated response of the nearby piezometers was also observed in the previous year.

Some piezometric levels shown on the instrumentation section in Appendix VI appear to be at an elevation that is higher than the base of the dam fill. This is not the case, since these instruments are offset from the section. A review of each instrument location confirms that the piezometric levels in this area are below base of the dam fill.

A local rise in foundation piezometric levels was measured in response to commissioning of the temporary on-dam slimes cell at the NBB starting in late August 2018. Piezometric pressures began to dissipate in September while the cell was still in operation, suggesting that the cell walls may have become sealed by slimes thus reducing seepage losses, similar to behaviour observed at the VBBE. The resulting rise at LL-VWP96-02B exceeded the T1 threshold value but T1 actions were not triggered because it was an isolated response, was less than the piezometric level measured during 2018 freshet and based on sensitivity analyses does not have a significant negative effect on the stability of the dam.

Inclinometers

There are four inclinometers installed in the NBB dam segment: I10-12 (~Sta. 2+450, dam toe); I15-25 (~Sta. 2+500, lower bench); I17-22 (~Sta. 2+550, mid bench); and I17-24 (~Sta. 2+600, upper bench). There are no movement zones at or near threshold values which propagate in a downstream direction between instruments. In comparison to movements in the glaciolacustrine deposits, shear movements in the mudstone layers are along discrete shear planes. General observations from each instrument are as follows (listed in order starting with most upstream moving downstream):

- I17-24:
  - In response to 2018 construction loading a movement along a discrete shear plane in a mudstone layer was measured at ~El. 1157 m. The shear zone measured at I17-24 is at a

similar elevation to the movements measured at the nearby I91-1 (now defunct) measured in the early 1990s.

- The peak movement rate measured, 2.1 mm/month, was below T1 threshold value and occurred between November and mid-December 2018. Starting in late December, the movement rate started to reduce based on the first readings taken following suspension of fill placement at the North Dam. Since late-December, the average movement rate has been ~1.2 mm/month.
- The timing of the movements at I17-24 coincided with movements observed in the adjacent section of the North Dam (I98-2, I98-3 and I99-5) but the direction of movement at both locations differed: southwest at I17-24; and northwest at the North Dam. Based on geologic characterization, the mudstone layers beneath NBB and North Dam are separated by zone of volcanics. These observations indicate movements at I17-24 and the nearby North Dam were both a response to construction loading but are not along a laterally continuous mudstone plane. The different directions of movements also provide clear evidence that the dam performance in this area is strongly influenced by three-dimensional effects.

- I17-22 – the incremental displacement plot shows no discrete shear zones in the bedrock or any movement zones in the glacial overburden during construction loading. At this location, Glacial Till is present at the elevation of the movement measured at I17-24 (i.e. ~El. 1157 m). A thin mudstone layer (~0.5 m) was logged in the drill core extracted from this location at ~El. 1128 m and no shear zones were measured at that elevation.
- I15-25 – the incremental displacement plot shows no discrete shear zones in the bedrock foundation during construction loading. Mudstone layers were logged at this location below ~El. 1155 m and no shear zones were measured at those elevations.
- I10-12 – the incremental displacement plot shows no discrete shear zones in the bedrock or movement zones in the glacial overburden during 2018. Mudstone layers were logged at this location below ~El. 1130 m and no shear zones were measured at those elevations.

5.5.5 North Dam: Sta. 2+800 to Sta. 3+900 (North Abutment)

North of ~Sta. 3+250, the North Dam foundation mainly comprises glacial deposits overlying bedrock. Immediately north of the NBB between Sta. 2+800 to ~Sta. 3+250, bedrock is shallow or at surface. In general the depth to bedrock increases to the north. Lenses and a continuous layer of glaciolacustrine are present in the glacial deposits, a portion of which was excavated, where practical, during 2018 foundation preparation. Where thick glacial deposits are present, the stability is primarily controlled by the continuous Upper-Glaciolacustrine unit. Where bedrock is shallow or at surface, the stability is primarily controlled by the mudstone layers in the Sedimentary bedrock which are overlain by dam fill and the Volcanic bedrock sequence.

T1 or T2 actions, refer to Figure 5.5, were not triggered during 2018 at the North Dam. Instrumentation summary plots for the North Dam (also referred to as the North Abutment) can be found in Appendix IV (inclinometers) and Appendix V (piezometers). Instrumentation readings are

plotted on a typical cross section through the North Dam at Sta. 2+800, Sta. 3+300 and Sta. 3+630, refer to Appendix VI.

Piezometers

Foundation piezometric conditions change towards the North Abutment. Beneath most of the dam, there is typically a significant downward gradient in the foundation whereby the piezometric levels tend to decrease with depth. This is not the case north of about Sta. 3+500 where the piezometric levels in all glacial overburden units project to a similar elevation range. This observation is evident when comparing the piezometric levels plotted on instrumentation section at Sta. 3+630 (Appendix VI) to the other instrumentation sections through the dam.

In addition, the piezometric head drop across the dam core north of Sta. 3+500 is much less than the rest of the dam and the majority of foundation piezometers downstream of the dam core show a response to rising pond level which is also not characteristic for other dam segments. This response started in 2005 when the pond level rose above El. 1225 m which was high enough to influence the natural groundwater levels controlled by the northern slope. Prior to 2005, the natural groundwater levels were higher than the pond level and followed a seasonal pattern with no significant year on year rise.

This difference in behaviour is due to the presence of the surficial Upper Sand and Gravel unit which forms a wedge that starts above the ultimate dam crest on the north slope and pinches out to the south near Sta. 3+500. The unit is more than 20 m thick along portions of the dam centerline and extends approximately upstream of the dam core and tailings beach. North of the NBB the dam core was keyed into either weathered bedrock, Glacial Till or what was described in historical project records as a stiff clay which is likely the Upper-Glaciolacustrine unit. However, as the thickness of the Upper Sand and Gravel unit increased to the north it became impractical to continue to key the dam core into the Upper-Glaciolacustrine or Glacial Till; therefore, the dam core was terminated into the Upper Sand and Gravel unit. The much reduced head loss from upstream to downstream of the dam core, as observed north of about Sta. 3+500, reflects the lack of an effective cut-off.

At the end of 2018, foundation piezometric levels were typically in the order of 1 m, up to 2 m, higher than the end of 2017. On average this was a slightly higher rate of rise than in recent years which may be related to the increase in pond volume during 2018. The rate of rise is the greatest in the upstream piezometers and progressively attenuates in the downstream direction, as would be expected.

Rising piezometric levels in the foundation have been considered in design. The improved monitoring capability and processes implemented over the past 2 years provides additional opportunities to monitor field behaviour for comparison to design assumptions and to refine future predictions. In addition, the life-of-mine deposition plan includes development of a wider tailings beach at the North Abutment to push the water pond further upstream which will increase the seepage gradient and reduce the seepage rate through the Upper Sand and Gravel unit.

Other observations made from 2018 piezometers at the North Dam include:

- The rise in piezometric levels observed in some instruments (e.g. LL-VWP16-03B and LL-VWP16-04A) which started in November 2017 and continued into February 2018 was a response to beaching at the North Abutment.
- During freshet (April to May) several NL threshold exceedances were recorded. None of the piezometric conditions reached a level which could trigger a dam safety concern or T1 actions. The levels measured during freshet, or similar, are expected to occur annually but manual readings done in the past have been too infrequent or the measurement period used to define 2018 threshold values too short to capture typical freshet peaks. In cases where this condition existed, the threshold value for that instrument was temporarily suspended until a longer measurement period with automated readings had been collected became available to support selection of more appropriate NL threshold values.
- A rise in piezometric levels was observed during hydraulic placement at piezometers installed in the Stratified Glacial Till, Upper-Glaciolacustrine and Upper Sand and Gravel units. The magnitude of the response was greatest at piezometers in the placement area with an attenuated response, if any, observed in piezometers downstream of the dam toe. The largest response, a 5 m rise, was observed at LL-VWP16-05A which is installed in the Stratified Glacial Till. The rate of dissipation following the end of construction was greater at the North Dam than typically observed at the VBB. At LL-VWP16-05A, the rate of dissipation since mid-December was approximately 1 m/month.

Inclinometers

There are 8 inclinometers installed in the North Dam:

- Bedrock shallow or at surface: I99-5 (~Sta. 2+800, upper slope[6]); I98-2 (~Sta. 2+850, lower slope); I98-3 (~Sta. 3+350, upper slope); and I10-3 (~Sta. 3+150, mid slope).
- Thicker glacial deposits overlying bedrock: I16-5 (~Sta. 3+350, lower slope); I16-1 (~Sta. 3+500, lower slope); I99-6 (~Sta. 3+600, mid slope); and I16-4 (~Sta. 3+750, dam toe).

The discussion of inclinometer measurements will be separated based on the 2 general foundation conditions found in this portion of the dam.

In the area where bedrock is shallow or near surface, discrete shear movements were measured within inferred mudstone layers and within a thin (< 2 m) overburden layer between the dam fill and bedrock at I10-3. General observations from each instrument are as follows (listed in order moving north towards the abutment):

- I99-5 – This inclinometer was destroyed during construction (mid-September). In 2019, THVCP reinstated the instrument by installing an SAA down the casing. During the available measurement period in 2018, increased movement rate is apparent at 2 elevations starting in

[6] Location for all North Dam inclinometers refers to position after 2018 fill placement.

early 2018, prior to construction. The rate at both movement zones was ~1.2 mm/month. However, there were several factors which indicate the movements may not be representative and not an indication of a dam safety concern:

- This movement was not measured at any of the adjacent instrument, indicating that, if representative, the movement was isolated.
- During the most recent fill placement in this area, 2012 to 2013, a discrete shear movement was measured at ~El. 1150 m. Movement zones in 2018 were above (~El. 1164 m) and below (~El. 1143 m) the previous movement zone.
- The movements started before any fill placement on the dam and the last readings collected, which was during the period when the location was being loaded, indicate the movement had stopped or slowed.
- The movement at ~El. 1164 m indicated a discrete movement primarily along the B-axis (parallel to the centreline) and the movement at ~El. 1143 m did not indicate a discrete movement.
- This instrument was destroyed prior to THVCP completing spiral correction which may be influencing the measurement plots.

- I98-2:
  - Movements were measured for the first time at this instrument during 2018. Prior to 2018, I98-2 was downstream of the dam toe and had not been loaded by fill. During 2018, the dam toe was extended downstream of I98-2 and up to 15 m (measured vertically) of fill was placed over the instrument and surrounding area. The movements were along discrete planes, inferred to be mudstone layers, at ~El. 1126 m and ~El. 1101 m.
  - The movement rate measured along both shear planes was approximately 1.2 mm/month from September 2018 through December 2018. Rates reduced starting in January after nearby fill placement was completed and current movement rates are less than 0.2 mm/month.
  - Some of the cumulative movement over time plots for I98-2 in Appendix IV indicate an apparent increase in movement rate in January 2019. However, a close review of the data indicated that the readings were not representative and had to be resolved by applying a rotation correction. An additional plot has been added showing the same inclinometer readings processed with the rotation correction and shows no increase in movement rate.
  - Movements within the mudstone layers are prevented from developing into a global failure plane by the passive wedge at the toe comprised of higher strength Volcanic and non-mudstone Sedimentary units. No displacement zones were measured in the Volcanic bedrock at I98-2 during 2018 or in previous years when the instrument was downstream of the toe.
- I98-3 – starting after September, as the 2018 fill placement approached I98-3, the movement rate along a shear plane at ~El. 1107 m, inferred as a mudstone layer, began to increase.

Movements had been measured at this same elevation in response to loading between 2011 and 2012 (KCB 2018e). Since fill placement was suspended in mid-December, the movement rates has been approximately 0.75 mm/month.

- I10-3:
  - The incremental displacement plot shows a movement zone that developed in response to 2018 fill loading, within a thin layer (< 2 m) between dam fill and bedrock which was logged as Glacial Till. The peak movement rate, 4 mm/month to 5 mm/month, occurred between October 2018 and December 2018. After fill placement was completed, the movement rate reduced to an average 0.5 mm/month since late December 2018.
  - Before 2018, this area had not been loaded since 2011, when an estimated 10 m to 12 m thick zone of fill (measured vertically) was placed along the downstream face of the dam. In response to that load, 2.6 mm of cumulative displacement was measured within this same layer.
  - The movement rate and shape of the measured displacement curve are similar to those observed in the normally consolidated lacustrine clay layer at the VBB. As part of 2018 construction, the footprint downstream of the instrument was cleared of any unsuitable materials down to competent Glacial Till or weathered bedrock. If there is a zone of normally consolidated clay beneath the dam fill at I10-3 it is not continuous to the current downstream toe.
  - During foundation preparation, a depression (approximately 2 m deep) in the bedrock surface filled with glaciolacustrine deposits was encountered near Sta. 3+200, approximately 3 m downstream of the existing dam toe. The deposits were removed and replaced with compacted fill and no other clay deposits were observed south of this point. The movement zone at I10-3 may be in a similar, locally confined zone of glaciolacustrine deposits which was not removed as part of foundation preparation.
  - Due to the foundation preparation activities undertaken and increased resistance at the toe from the fill which had been placed downstream at the time, the movement rate at I10-3 did not represent a significant dam safety concern and T1 actions were not required.

The measured movements within the bedrock initiated a review of the geology, foundation characterization, historic behaviour, design basis, design assumptions and expected performance for this portion of the dam. This was done to confirm that 2018 observations did not indicate actual conditions were different than assumed. The review concluded that the movements were consistent with current design basis and performance expectations based on:

- movement rates, during loading, were consistent with historic trends;
- movement rates slowed after construction loading which is indicative of “stable” movements;
- two-dimensional stability analyses indicate adequate factors of safety (> 1.5) assuming conservative assumptions:

- As previously indicated, dam performance in this area is highly influenced by a favourable three-dimensional environment, which would provide additional stabilization benefits not captured by two-dimensional analysis.

Although performance was consistent with design, THVCP and KCB agreed to implement additional steps to improve the ability to monitor this area during active construction, which included updating thresholds for 2019 incorporating observations from 2018 and installation of 4 additional inclinometers along the ultimate toe of the North Dam to improve instrument coverage and redundancy. The instruments were installed in early 2019 and are not reported herein.

In the area where the stability is controlled by the glaciolacustrine within thicker glacial deposits, there are no movement zones at or near threshold values which propagate in a downstream direction between instruments. General observations from each instrument are as follows (listed in order moving north towards the abutment):

- I16-5 – An IPI was installed at this location, across the extent of the Upper Glaciolacustrine, for the same reason as the downstream inclinometers at the VBB. Movements measured between July 2017 and December 2017 are related to the formation of a compression zone in the casing, not a downstream movement. After this, negligible incremental movement was observed across the instrument. Starting in September 2018 the instrument measurements were being influenced by the compression zone. THVCP removed and reinstalled the IPI multiple times as they attempted to resolve the issue. This is the reason for the irregular movements shown on the summary plot (Appendix IV). Readings collected since the issue was resolved in December 2018 show no incremental movement over the Upper Glaciolacustrine unit.
- I16-1 – An IPI was also installed across the extent of the Upper Glaciolacustrine unit at this location. A compression zone in the casing straddled the base of the Upper Glaciolacustrine unit and the underlying Glacial Till. The movements measured across Upper Glaciolacustrine unit were not representative as they were being influenced by the compression zone. If the incremental movement is measured from the top of the Upper Glaciolacustrine unit to the base of the compression zone, the results are similar to I16-5. Measurements from later in 2018 are also being influenced by THVCP removing and reinstalling the instrument. After several attempts to correct the issue, THVCP opted to switch back to manual readings starting in January. A movement zone in the dam fill was measured in the initial manual readings during 2019. The movement rate is below threshold and THVCP are planning to apply the spiral correction to I16-1.
- I99-6 – is located north of the 2018 fill placement areas but was damaged in October 2018 during re-establishment of an access ramp in the area. In 2019, THVCP reinstated the instrument by installing an SAA down the casing. There are compression zones along the casing. No unrelated downstream movement zones were recorded during 2018.
- I16-4 – is located at the ultimate dam toe, foundation preparation to the ultimate toe in this area was completed prior to 2018. Even if this portion of foundation was prepared in 2018 it

would have been impractical to remove the Upper-Glaciolacustrine unit from the footprint in this area due to the depth below ground. The design of the dam segment has taken this into account. This area was not loaded in 2018 other than the till core zone raise and some upstream cycloned sand placement. The incremental displacement plots do not indicate significant shear movements during 2018 within the glaciolacustrine deposits.

5.6 H-H Dam 2018 Measured Instrumentation Response Summary

Piezometers

The majority of the existing instruments at the H-H Dam were installed during 2017, so there is limited historic information to compare performance against. The additional instrumentation allows for more confidence in assessing actual behaviour in comparison with design assumptions. At the start of 2018 many of the new instruments were still equilibrating from installation and have now established a reasonable baseline. General observations from the piezometer data are:

- Piezometric levels in the dam fill generally grade towards 24 Mile Lake, ranging from El. 1210 m to El. 1215 m near the core and ~El. 1202 m at the slope toe. In 2018, the water level in 24 Mile Lake was on the far side of the facility relative to the dam but the tailings are still likely saturated and the lower permeability of the tailings act as a restriction on flow.
- There is one instrument installed in the dam fill upstream of the core zone (HH-VWP15-22) which measured a head ~El. 1262.5 m at the end of 2018 which is ~3 m less than the peak value from 2017. During 2018, most of the deposition was upstream of the tailings cone near the east abutment resulting in very little tailings flowing over or water ponding on the tailings immediately upstream of the dam relative to 2017.
- The general stratigraphy in the dam foundation along the middle of the valley (~Sta. 1+200 to Sta 1+850), listed in descending order, comprises of: Glacial Till; Clay Layer 2; and Sand and Gravel:
  - With the exception of the outlier at HH17-33A, piezometric levels in the Sand and Gravel suggest the piezometric level grades from the abutments (to the base of the natural valley). Where multiple piezometers are installed at a single location, the water level in the Sand and Gravel is less than measured in the overlying unit, suggesting a downward gradient.
  - Piezometric levels measured in the unit referred to as Clay Layer 2 show the opposite pattern as the values in the dam fill where the piezometers levels are higher near the dam toe (~El. 1218 m) than near the dam core (El. 1207 m). This trend is under further review.
  - With the exception of the outlier at HH17-32B, piezometric levels in the glacial till in the middle of the valley and East Abutment range between El. 1215 m and El. 1220 m.
- There are a limited number of data points and measurement period available but in general the piezometric conditions in all of the units are within the same general range and relatively level or shallowly graded, with the exception of some outliers.

- The stability of the H-H Dam is governed by the post-earthquake condition of the saturated, loose dam fill (Section 7.2.2). Foundation piezometric conditions are well below levels required to reduce the factor of safety of the existing dam below criterion.

Inclinometers and Settlement

In 2017, six inclinometers were installed at new locations across the H-H Dam. Sondex settlement monitoring systems were installed at 4 of the inclinometer locations. Also in 2017, an additional 2 Sondex settlement monitoring systems (HHI17-29A and HHI17-32A) were installed near existing inclinometers (HHSAA12-1 and HHI15-23).

HHI17-29A and HHI17-32A also include inclinometer casing but they are mainly used for the Sondex installations and are not read as part of routine monitoring for horizontal movements. They are installed as back-up in case HHSAA12-1 and HHI15-23 are damaged. Instrument location and names are summarized in Table 5.5.

Table 5.5 Summary of Inclinometer / Sondex Installations at H-H Dam

Location	Inclinometer / Sondex					
	Sta. 1+200	Sta. 1+280	Sta. 1+460	Sta. 1+600	Sta. 1+700	Sta. 2+020
Near Core Zone	HHI17-33 / HHI17-33A	HHSAA12-1 / HHI17-29A	HHI15-23 / HHI17-33A	-	HHI17-16 / HHI17-16A	-
Crest of Fill Slope	-	-	-	HHI17-17 / HHI17-17A	-	-
Toe of Fill Slope	-	-	HHI17-31A / -	-	HHI17-30 / -	HHI17-14 / HHI17-14A

H-H Dam inclinometers in the dam fill have shown relatively large horizontal movements distributed fairly uniformly in the upper fill zones. This dam fill was placed in thick lifts (up to 10 m) and the horizontal movements were interpreted to be settlement related. The Sondex systems were installed to collect information to validate that assessment.

Summary plots of inclinometer and Sondex monitoring are included in Appendix IV. Measurements from the instruments indicate the following:

- Near Core Zone:
  - No zones of sustained downstream movement were measured in the dam foundation at any of the inclinometers.
  - All of the inclinometers show some degree of horizontal movement in the waste fill above ~El. 1208 m. This elevation roughly corresponds to the transition between waste fill placed in thick lifts and the structural fill placed to support the initial raises above the starter dam. This fill was placed and compacted in ~2 m lifts.
  - A comparison of inclinometer and Sondex measurements does support the interpretation that the horizontal movements in the upper fill is primarily related to fill settlement. The

locations of the largest settlement (HHI17-33A and HHI17-16A) correlates to the areas with the most horizontal movement.

- The Sondex systems were installed from the top of fill at the time of drilling down to ~El. 1225 m. Additional settlement may be occurring below this level that would not be measured by the Sondex rings.

- Crest of Fill Slope – the same pattern of horizontal movement and settlement is observed at I17-17/I17-17A. The zone of horizontal movement extends deeper to ~El. 1198 m. This location is closer to the toe of the structural fill slope so that the depth to structural fill is greater than at locations near the core.
- Toe of Fill Slope:
  - Both of the inclinometers along the toe upstream of 24 Mile Lake (HHI17-30 and HHI17-31A) show compression zones along their depth but there are no zones of sustained downstream movements in the foundation. The same pattern of horizontal movement in the fill observed at the dam crest is not present at these locations.
  - The incremental movement plots for the inclinometer installed near the dam toe upstream of the lock-block wall (HHI17-14) shows negligible horizontal movements in the fill or foundation. The Sondex at the same location (HHI17-14A) is measuring relatively small amounts of settlement.

Survey monuments

Survey monuments installed on the lock-block wall at the toe of the H-H Dam, near the HH Pumphouse, were monitored in 2018 in the period prior to, during and after construction (Appendix VIII). All of the monuments show similar pattern of little to no movement. A spike in movement rate was measured at all locations in October 2018 which corresponds with a crest raise. The spike dissipated based on the next reading. However, the cumulative movement for those readings is small, typically less than 3 mm. The October readings are typically outliers in terms of Northing, Easting location to the readings prior to and after.

There was no sustained trend of increasing movement which would indicate a stability concern with the structure. The readings at all of the monuments fall within a 2 mm to 4 mm variance in Northing and Easting which is within the typical survey accuracy.

5.7 Seepage

5.7.1 L-L Dam Seepage

Seepage weirs continued to be monitored at the L-L Dam, refer to Appendix VII for a summary plot of measured flows. Of note is that all of these weirs are downstream of the dam and collect surface flows as well, which is apparent in some of the responses. LL-FS-03 was removed in 2018 as it was within the footprint of the Seepage Pond 1 decommissioning and foundation preparation. The DSR recommended that THVCP should review seepage monitoring plan at the L-L Dam. KCB supports this recommendation and part of that review should include whether a replacement for LL-FS-03 is

required. A replacement has not been installed to date. Flows from other seepage weirs were consistent with recent years:

- LL-FS-01 – flow rates and pattern were similar to recent trends up to October when flow rates rose and remained elevated level until they started to dissipate in November. This coincides with hydraulic sand fill placement on the North Dam which would have increased seepage flows through the blanket and underdrains which report to LL-FS-01. The spike in freshet is related to an increase in surface flows reporting to the weir and temporary ponding on the north side of the NBB.
- LL-FS-02 – a similar trend in flow rates to LL-FS-01 were measured at LL-FS-02 where flow rates increased in October in response to hydraulic sand placement. The largest flow rates measured in recent years was during 2014 when hydraulic placement was completed at the VBBE immediately upslope of the weir. Measured flows still showed a response to placement at the North Dam but to a lower degree.
- LL-FS-04 – measures outflow from Seepage Pond 2 rather than flow directly from the dam toe or underdrain. Flows in 2018 were elevated than recent history, this was the result of both Slimes Pond 2 and Seepage Pond 2 being utilized for slimes storage. There were similar spikes when Slimes Pond 2 was last used during 2015 construction. The higher rates observed in 2018 compared to 2105 are likely related to increased cycloned sand production rate and a larger catchment reported to Seepage Pond 2 during 2018 freshet.

5.7.2 H-H Dam Seepage

There are no seepage measurement points at the H-H Dam.

5.8 Water Quality

Water quality downstream of the Highland TSF is monitored by HVC monthly to assess the effectiveness of the tailings facility in protecting the downstream receiving environment. A copy of the HVC 2018 Annual Water Quality Monitoring Report (ERM 2019) was provided to KCB for review as part of the DSI. Select observations and findings from the monitoring report are summarized as follows:

- There are six permitted surface water quality monitoring sites in the L-L Dam/Thompson Valley area, as shown on the site monitoring plan in Appendix IX. There are no surface monitoring points in the immediate area downstream of H-H Dam however there are two ground water wells sampled quarterly.
- All sampling sites except one were in compliance with the required sampling frequencies and parameters. Some field parameters were not recorded for June sampling event in 2018 at the Highland Valley Tailings Pond Supernatant site (HVC-101).
- The 2018 monitoring results were screened against applicable BC Water Quality Guidelines (WQG). However, it should be noted that the WQG are not prescribed performance targets in permit PE-376.

- The receiving environment downstream of the dam indicated some WQG exceedances in 2018 which may be attributed in part to the following factors:
  - Influence from naturally occurring elevated background levels;
  - Particulate transport during the relatively high freshet flows;
  - Seepage from L-L Dam and unlined seepage collection ponds;
- Longer term trends in the receiving environment downstream of the dam indicate that Sulphate, Fe, Mn and Mo as Mo have been increasing over time, which may be attributed to seepage from the L-L Dam and unlined seepage collection ponds.

Further discussion on specific WQG exceedances and water quality trends observed during 2018 can be found in the 2018 Annual Water Quality Monitoring Report (ERM 2019).

THVCP have implemented the Sulphate Adaptive Management Plan to mitigate influence of seepage from the Highland TSF on downstream water quality and increase water available to downstream users in Pukaist creek. This is a multi-year program which includes installation of interception wells downstream of the dam, lining of seepage collection ponds and diversion of non-contact water around the TSF and into Pukaist Creek.

In 2018, KCB recommended that the permitted monitoring well be moved from LL-MW09-04A to LL-MW18-11. LL-MW18-11 is screened in the Lower Sand and Gravel which and is in a preferred location for monitoring of seepage from the Highland TSF.

6 DSI SITE VISIT VISUAL OBSERVATIONS

The visual observations made during the September DSI site visit are summarized below, a copy of the L-L Dam and H-H Dam inspection forms are included in Appendix I. The referenced site inspection photos are included in Appendix II.

L-L Dam

- **Crest and Upstream Slope:** Good physical condition, no visual indicators of concern. Some erosion of upstream face of the upstream cycloned sand zone near spigot points. This is localized and restricted to the overbuilt portion of the sand zone. These occurrences were noted and monitored as part of weekly inspections. No associated dam safety issue. (Photo II-A-2, Photo II-A-5, Photo II-A-6 and Photo II-A-8)
- **South Abutment:** Good physical condition, erosion or excessive seepage not observed.
- **North Abutment:** Good physical condition, erosion or excessive seepage not observed.
- **North Dam:** No observed dam safety issues of concern. At time of inspection, active construction included placement of downstream cycloned sand. Observed hydraulic placement cells in various states of activity (prepared, recently completed and in progress). Construction quality control and quality assurance were being undertaken for this work as described in the construction record report (KCB 2019). (Photo II-A-10, Photo II-A-12 and Photo II-A-13)
- **NBB:** No observed dam safety issues of concern. The only construction activity ongoing during the inspection was the temporary on-dam slimes cell in one of the berm benches. No observations of concentrated seepage or other potential issues of concern along the perimeter slopes downstream of the cell. (Photo II-A-9 and Photo II-A-11)
- **VBBE:** No observed dam safety issues of concern. No ongoing construction activity in this dam segment during the inspection. Hydraulic fill placement on the upper portion of the slope, to support the till core raise, was completed in August 2018. The temporary on-dam slimes cell was not in operation and left to dry to each slimes removal which was undertaken at a later date. (Photo II-A-16)
- **VBB:** No observed dam safety issues of concern. No ongoing construction activity in this dam segment during the inspection. Hydraulic fill placement on the upper portion of the slope, to support the till core raise, was completed in August 2018. There was some erosion of the slope caused by spills from hydraulic placement cells however, these are limited in size and do not pose a dam safety concern. Each were reviewed by KCB when they occurred. They were remediated where practical, where not, they will be repaired as part of the next fill raise which will bury the existing slope. Earlier in the year, the foundation area downstream of the VBB toe, including Seepage Pond 1 and Slimes Pond 1 had been prepared for fill placement in 2019. (Photo II-A-1, Photo II-A-14 and Photo II-A-16)
- **South Dam:** No observed dam safety issues of concern. No ongoing construction activity in this dam segment during the inspection. Hydraulic fill placement on the upper portion of the

slope, to support the till core raise, was completed in August 2018. 2018 construction did include some foundation preparation where the ultimate toe was extended downstream. Slope erosion from hydraulic placement cells did occur in 2018 which were reviewed and managed similar to the process described at the VBB. (Photo II-A-1, Photo II-A-15 and Photo II A-16)

- **Tailings Beach:** Good physical condition. THVCP increased tailings discharged from dam crest to widen beach between upstream cycloned sand fill and pond. Beach is widest at the north end as the location of the pond reclaim barge limits achievable beach width at south end. (Photo II-A-2 and Photo II-A-4)
- **Pond:** At the time of September site inspection, the pond was at El. 1251 m which is 9.5 m below the crest of the dam at that time (El. 1260.5 m).
- **Seepage and Toe Collection Ditches:** Where present, primarily from the underdrains, seepage emanating from the dam fill was clear with no turbidity. Some turbidity can be observed in downstream ditches but that is related to surface water flows. All water reports to a downstream collection pond and is reclaimed back to the impoundment via the SWRP. One seepage point (FS-03) downstream of the VBB toe was decommissioned as part of Seepage Pond 1 backfilling. Seepage flow from VBB toe is now pooling in the backfilled Slimes Pond 1. Water is temporarily being pumped from Seepage Pond 1 to SWRP until a surface ditch is excavated to allow gravity drainage.

H-H Dam

- **Crest:** Good physical condition, no visual indicators of concern. The crest raise was in progress during the inspection. Construction quality control and quality assurance were being undertaken for this work as described in the construction record report (KCB 2019). Cracking in the fill surface, similar to that noted in the fill during the 2017 DSI, were not observed. The cracking observed in 2017 was monitored to confirm they were local features and not indicators of large-scale movements of concern. Where appropriate, the areas had been remediated by excavating and backfilling, after which they did not reappear. (Photo II-B-1, Photo II-B-4 and Photo II-B-10):
- **West Abutment:** Good physical condition erosion or excessive seepage not observed. During the site inspection the west abutment foundation preparation was in progress. Surface waste and glacial till were being removed to exposed competent bedrock at the till core contact. (Photo II-B-2)
- **East Abutment:** Good physical condition erosion or excessive seepage not observed. Foundation preparation was completed prior to the inspection and fill placement was further advanced relative to the west abutment. (Photo II-B-7 and Photo II-B-10)
- **Upstream Slope / Tailings Beach:** Good physical condition, no erosion of the fill or indicators or concern (e.g. sinkholes) were observed on the beach surface. Fill platforms had been built from the H-H Dam crest on to the tailings beach surface to support site investigations

completed in 2018 to characterize the tailings near H-H Dam. (Photo II-B-3, Photo II-B-4 and Photo II-B-10)

- **Downstream Slope:** No observed dam safety issues of concern (e.g. slumping, cracking or large scour). (Photo II-B-5, Photo II-B-8 and Photo II-B-9)
- **Lock-Block Retaining Wall:** Generally good physical condition. Instrumentation installed in 2017 (survey prisms, 1x VWP, 1x inclinometer and 1x Sondex settlement system) to monitor global stability of the dam in this area remain operational. Local stability of the wall, similar to the original design, is by Others. (Photo II-B-7)
- **Seepage:** No seepage was observed at the toe of the H-H Dam.
- **24 Mile Lake:** No observed dam safety issues of concern related to H-H Dam observed. THVCP had placed additional waste in the I-9 Dump in 2018 which had no observable impact on H-H Dam. There is some erosion of the waste dump bench slopes around the perimeter of 24 Mile Lake; however, these do not pose a risk to H-H Dam safety and as discussed in Section 2, there is no credible dam type failure mode for 24 Mile Lake. (Photo II-B-11, Photo II-B-12 and Photo II-B-13)

L-L Dam Seepage Collection and Slimes Ponds

- **Seepage Pond 1:** Area was decommissioned in 2018 as discussed in Section 3.2.2. (Photo II-C-4, Photo II-C-7 and Photo II-C-9)
- **Seepage Pond 2:** No dam safety concern observed. As discussed in Section 3.2.2, Seepage Pond 2 was used for slimes storage in 2018 due to shortfall. Slimes do not impede the pond outlet or significantly impact flood routing. However, THVCP are to confirm long-term plan for Slimes Pond 2 (i.e. will slimes be removed and return to original operation) and assess whether design modifications are appropriate. (Photo II-C-5, Photo II-C-6 and Photo II-C-8)
- **Slimes Pond 1:** Area was excavated and backfilled in 2018 as discussed in Section 3.2.2. (Photo II-C-9)
- **Slimes Pond 2:** No dam safety concern observed. Pond was filled to capacity with slimes during 2018. Some slimes removal was undertaken in 2018, include a dredging trial (after site inspection). (Photo II-A-14)
- **Slimes Pond 4:** Facility was recommissioned in 2018 to address slimes storage short fall as discussed in Section 3.2.2. Slimes removal commenced in late 2018 and was schedule to continue into 2019. KCB recommended THVCP confirm the long-term plan for Slimes Pond 4. (Photo II-C-4)
- **Seepage Water Reclaim Pond:** No dam safety concern observed. During freshet, the culvert that conveyed outflow from the Jim Black Lake across the road into SWRP was clogged with sediment. THVCP replaced the culvert later in the year. (Photo II-C-1, Photo II-C-2 and Photo II-C-3)

7 ASSESSMENT OF DAM SAFETY

7.1 Dam Classification and Design Basis Review

The consequence classification of each of the dams included in the Highland TSF (as summarised in Table 2.1) is reviewed annually by THVCP and KCB's EoR or designate representative at the time. The most recent review was performed on January 23, 2019. No change in consequence classification was recommended.

An updated consolidated design basis summary was prepared in 2018 for the L-L Dam and submitted as part of the engineering report to support the L-L Dam permit application (KCB 2018d) which is currently under review by EMPR. The updated design basis does not significantly change the core criteria or requirements from those in the approved design report (KCB 2010). Any changes made were to update applicable references to reflect current information and clarify specific items. No other changes to the design basis for L-L Dam or H-H Dam were implemented during 2018.

As discussed in Section 2, KCB completed a review of 24 Mile Lake which concluded that, in its current configuration, there is no credible failure mode for the containment structure that could lead to an uncontrolled release of tailings or water, nor result in offsite impacts. In KCB's opinion, 24 Mile Lake should not be classified as a dam and continue to be managed as an appurtenance of the H-H Dam.

7.2 Failure Mode Review

7.2.1 Overview

Based on the DSI and review of available documents regarding the L-L Dam and the H-H Dam, the potential geotechnical and hydrotechnical failure modes included in the CDA Dam Safety Guidelines (CDA 2013) were reviewed and discussed below. THVCP commissioned a Failure Modes and Effects Analysis (FMEA) risk assessment for the L-L Dam and H-H Dam which was facilitated by the Wood Group and KCB also participated. The FMEA was completed over a series of workshop and follow up discussions in December 2017 to January 2018. The assessment included a review of design and operation controls for each of the dam safety failure modes. Based on the FMEA, the current failure mode risks were found to be well understood and well managed. No material changes to the risk classifications were necessary. The FMEA summary document is in progress and will be issued in 2019.

KCB note that the design, construction and operations of the L-L Dam and the H-H Dam are an ongoing process and structured based on the Observational Method where applicable, as described in KCB (2018d).

7.2.2 L-L Dam

Overtopping

The Highland TSF is designed to contain the flood volume from the PMF (49.4 Mm^3) resulting from the average annual snowmelt runoff plus the 5-day PMP, which is a duration greater than required by

the Code. For reference, the operating freeboard during 2018 ranged from 9.1 m to 15.1 m, which is greater than the 2018 flood routing freeboard limit of approximately 7.5 m (~5.5 m to store IDF + 2 m of freeboard). At the end of 2018, after the dam crest raise to El. 1262.5 m the operating freeboard was 11.6 m. Crest elevation milestones in the construction schedule are designed to maintain storage capacity for a minimum of one full year in advance. Therefore, under current construction and operating conditions, the likelihood of overtopping is considered negligible.

Internal Erosion and Piping

Based on a 2015 review of filter adequacy (KCB 2015), the risk of piping related failure through the dam developing at this stage is very low. The dam design incorporates a wide upstream cycloned sand berm, and a vertical glacial till core supported by a downstream cycloned sand zone that is filter compatible with the core fill.

At the North Abutment, the glacial till core zone only provides a partial cutoff to seepage flow, since it terminates in the Upper Sand and Gravel Unit due to the deep elevation of impermeable Glacial Till. A review of the risks of internal erosion and piping at the North Abutment was carried out in 2016 (KCB 2017c). This included a review of available particle size distributions together with a review of measured and predicted hydraulic gradients for existing and ultimate conditions, which indicated that internal erosion mechanisms in the North Abutment foundation are not a concern (KCB 2017c). The ongoing design review includes additional assessment of future conditions based on results from site investigation data and seepage modeling completed since 2016.

A decommissioned Low-Level Outlet (LLO) remains close to the South Abutment of the dam. The downstream outlet of the LLO was surrounded with filter compatible fills in 2015, in order to mitigate the risks of piping (KCB 2014). Therefore, the likelihood of a piping related failure developing around the LLO is very low.

Stability

The dam is founded on a mix of Lacustrine clays (beneath the Starter Dam in the centre of the valley only), Glacial Till with interbedded Glaciolacustrine deposits, and a mix of granodiorite, volcanic and sedimentary bedrock units. The design of the L-L Dam accounts for the variability of the foundation conditions along its alignment, including buttresses where required by the localized foundation conditions.

Stability analyses are carried out on a regular basis, including prior to construction of each planned raise. In 2018, design review work to date included a review of plausible failure modes of each L-L Dam design segment to assess whether they are appropriately characterized and managed under the Base Case design. Structural stability failure modes were checked for the Base Case design based on the updated geologic and geotechnical characterization. The assessment (KCB 2018e) demonstrated that the existing condition of the L-L Dam meets design criteria. However, modifications to the Base Case are required at the VBB (shallow downstream slope from 2H:1V to 2.5H:1V) and North Dam (additional buttress between Sta. 3+200 and 3+700) to meet structural stability criteria as the dam is incrementally raised. THVCP have submitted a permit application to EMPR which is pending to incorporate these changes into the L-L Dam construction plan starting in 2020. No modifications to

the approved Base Case design were required at the NBB, VBBE and South Dam as the approved buttress designs met criteria based on the updated foundation characterization

In addition to the changes to the base case design, a Contingency Case design for the VBB (downstream extension of buttress), was included in the permit application to manage residual risks in that area, based on the Observational Method framework, related to failures through the glaciolacustrine deposits in the foundation of the VBB. The Contingency Case may or may not be required based on measured performance.

Based on the recent design assessments the likelihood of a dam instability is considered very low and can be appropriately managed in the future by incorporating to proposed modifications in KCB (2018d) which are pending approval from EMPR.

Surface Erosion

The downstream slope of the dam ranges from 2H:1V (in localised areas such as access roads) to 3H:1V. Where the slopes are steeper than 2.5H:1V, there is an increased risk of surface erosion, particularly during snow melt conditions, and erosion features are not uncommon during freshet. Progressive erosion that develops over time or multiple events are managed through routine and event-driven monitoring and ongoing maintenance. In terms of the overall size of the L-L Dam, these erosion features are small and the likelihood of surface erosion over the downstream slope resulting in a dam failure from a single event is negligible.

Earthquakes

Slope stability and deformation of the dam under seismic loading and post-earthquake conditions were assessed in 2010 stability analyses (KCB 2010) and reviewed as part of the 2018 design review (KCB 2018e). The 2018 design review was based on the updated site-specific seismic hazard assessment which was also completed in 2018 (KCB 2018c). The design earthquake loads from the 2018 seismic hazard assessment were similar to those assumed in the approved design (KCB 2010) and do not substantially change the assessment.

The design earthquake for the L-L Dam assumed for the analysis corresponds to a 10,000-year return period event (KCB 2018c). This seismic event is in accordance with the minimum earthquake design ground motion (EDGM) required under the Code; 10,000-year or maximum credible earthquake (MCE). The likelihood of a seismic-related failure is considered low.

7.2.3 H-H Dam

Overtopping

Overtopping of the H-H Dam is not a plausible failure mode in the current configuration because the crest is 10 m or higher than the L-L Dam crest on the opposite side of the impoundment. Therefore, the L-L Dam would be overtopped before the pond reached the H-H Dam crest.

Internal Erosion and Piping

Based on a 2015 review of filter adequacy (KCB 2015), the likelihood of piping related failure through the dam developing at this stage is very low. Of particular relevance, there is no free water pond adjacent to H-H Dam.

Stability

The dam is founded on a mix of Sand and Gravel, Glacial Till with interbedded Glaciolacustrine/Clay deposits, and granodiorite bedrock. KCB (2016n) indicated that, assuming Glaciolacustrine/Clay deposits are continuous layers, slope stability criteria are met because of their depth and thickness of confining overburden and fill layers.

Similar to L-L Dam, stability analyses are carried out on a regular basis, including prior to construction of each planned raise. Ongoing design review work have included a review of structural stability failure modes at H-H Dam based on the updated geologic and geotechnical characterization. The assessment which has not yet been formally issued, concluded that the existing condition of the H-H Dam meets design criteria. Moreover, to date, the instrumentation data has indicated generally satisfactory performance. Therefore, the likelihood of a dam instability is considered very low.

Surface Erosion

The downstream slope of the dam is approximately 2H:1V. The majority of the downstream face of the dam comprises rockfill, therefore it is not at risk of erosion. Some rilling of the surface is visible in the lower slopes where sand and gravel fills are exposed in the face. Progressive erosion that develops over time or multiple events are managed through routine and event-driven monitoring and ongoing maintenance. The likelihood of surface erosion over the downstream slope resulting in a failure from a single event is negligible.

Earthquakes

Part of the ongoing design and performance reviews of H-H Dam included consolidating the construction history which indicated the downstream shell fill is not all “rockfill” and has wide variation in waste type and gradations, including sand and gravel zones. Subsequent investigations, completed in 2017, confirmed the presence of loose sands and/or sands and gravels within the dam fill which may be susceptible to liquefaction if saturated.

As an initial screening tool, KCB completed a stability assessment of the post-earthquake condition based on very conservative assumptions where all saturated waste liquefies and has liquified strengths comparable to liquefied tailings. Under these conservative assumptions the post-earthquake stability criteria is met for the existing condition. Work is ongoing to confirm whether additional buttressing of the H-H Dam is required under a future loading condition to meet post-earthquake stability criteria.

7.3 Emergency Preparedness and Response

The 2018 OMS manual included an update to the emergency preparedness and response plan (EPRP) for the Highland TSF. This included a list of preventative measures which could be taken in response to various developing failure modes.

Training of THVCP staff and contractors who work near the dams is provided by a video presentation which outlines dam safety warning signs that all staff should be aware of and report if any are observed during their work.

In the case of an emergency an incident command center would be established on site to coordinate with regional emergency response organizations and local authorities as part of THVCP's Site Wide Emergency Response Plan. The roles and responsibilities of key team members of the tailings team that would support this response are defined in the OMS manual. THVCP's Emergency Reporting Procedure defines the reporting structures and who is responsible for declaring an emergency and starting the incident response.

Training and testing of the EPRP currently is done using desktop scenarios. Along with testing of the system, offsite emergency response resources are contacted regularly to ensure that contact information is still up to date. The emergency reporting contact list is also reviewed and updated as required. A table top exercise to review and update the Emergency Preparedness Response Plan for the HVC site was hosted by THVCP and attended by the EoR on November 22, 2018.

8 SUMMARY

The Highland TSF appears in good physical condition and the observed performance during the 2018 site inspections is consistent with the expected design conditions and past performance. The status of recommendations to address deficiencies and non-conformances identified during past DSIs are summarized in Table 8.1. Closed recommendations are shown in *italics*. Recommendations to address deficiencies and non-conformances identified during the 2018 DSI are summarized in Table 8.2.

Table 8.1 Status of Outstanding Recommendations for Deficiencies and Non-Conformances

ID No.	Recommended Action	Priority(1)	Recommended Deadline (Status)
L-L Dam			
LL-2015-01	*Downstream sand should be placed in over-steepened upper sections of the downstream dam slopes (between Sta. 1+050 m and Sta. 3+650 m) to the design (2.5H:1V) during the next construction season. Some re-work of the existing loose sand on these slopes will be required as the downstream sand is raised, to ensure these slopes meet compaction/density requirements.*	*3*	*CLOSED (design slopes established during 2018 construction)*
LL-2015-02	*The overflow lines from the secondary cyclones were buried with un-compacted cycloned sand across the upstream S2 zone during 2015. This sand will require re-working following completion of downstream sand placement during the next construction season.*	*3*	*CLOSED (pipes were removed during 2018 construction)*
LL-2015-06	We recommend that key design criteria for the Highland TSF, including the probable maximum flood (PMF), freeboard requirements and seismic ground motions be reviewed during 2016.	4	OPEN (Seismic hazard assessment update completed in 2018. PMF review in progress, to be finalized in 2019)
LL-2016-02	Install seepage measurement weirs at the outflow points of the North Dam (Sta. 3+600) and South Dam (Sta. 1+100) major drains to monitor seepage rates.	3	OPEN (*Locations to be defined in 2019 as part of Seepage Pond 4 design*)
H-H Dam and 24 Mile Lake			
None			
L-L Dam Seepage Collection and Slimes Ponds			
SP-2017-01	The Seepage Water Reclaim Pond has insufficient capacity to store the IDF and should be brought into compliance. Note: THVCP to include an interim plan involving pumping to manage the IDF without off-lease discharge until upgrade works are complete. Suggested interim milestones: Design in 2018, Permit and IFC in 2019 and Construction in 2020. *(Schedule updated in 2018)*	2	OPEN (In 2018 the design for upgraded pond was submitted for permit approval. Construction has been added to life-of-mine construction plan. To be completed by end of 2021.)
SP-2017-02	Regrade Seepage Pond 2 outlet pipe to a consistent downward grade	2	OPEN (Work scheduled for 2019 as part of Seepage Pond 2 slimes clean-out)

Notes:

1. Recommendation priority guidelines, specified by Teck and assigned by KCB:
   Priority 1: A high probability or actual dam safety issue considered immediately dangerous to life, health or the environment, or a significant risk of regulatory enforcement.
   Priority 2: If not corrected could likely result in dam safety issues leading to injury, environmental impact or significant regulatory enforcement; or, a repetitive deficiency that demonstrates a systematic breakdown of procedures.
   Priority 3: Single occurrences of deficiencies or non-conformances that alone would not be expected to result in dam safety issues.
   Priority 4: Best Management Practice – Further improvements are necessary to meet industry best practices or reduce potential risks.

Table 8.2 2018 Recommendations for Deficiencies and Non-Conformances

ID No.	Deficiency or Non-Conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority[1]	Recommended Deadline (Status)
L-L Dam					
LL-2018-01	Various	-	Review, complete and/or provide written response to close out all 2017 DSR recommendations.	3	Q1 2020
H-H Dam and 24 Mile Lake					
HH-2018-01	Various	-	Review, complete and/or provide written response to close out all 2017 DSR recommendations.	3	Q1 2020
HH-2018-02	Post-earthquake	10.1.8	Complete H-H Dam design review to confirm liquefaction susceptibility and dam stability under future loading conditions	2	Q4 2019
L-L Dam Seepage Collection and Slimes Ponds					
SP-2018-01	OMS	10.5.2	If Slimes Pond 4 to remain as contingency slimes storage, include it in the 2019 OMS manual update.	3	Q4 2019

Notes:

1. Recommendation priority guidelines, specified by Teck and assigned by KCB:
   Priority 1: A high probability or actual dam safety issue considered immediately dangerous to life, health or the environment, or a significant risk of regulatory enforcement.
   Priority 2: If not corrected could likely result in dam safety issues leading to injury, environmental impact or significant regulatory enforcement; or, a repetitive deficiency that demonstrates a systematic breakdown of procedures.
   Priority 3: Single occurrences of deficiencies or non-conformances that alone would not be expected to result in dam safety issues.
   Priority 4: Best Management Practice – Further improvements are necessary to meet industry best practices or reduce potential risks.

9 CLOSING

This report is an instrument of service of Klohn Crippen Berger Ltd. The report has been prepared for the exclusive use of Teck Highland Valley Copper Partnership (Client) for the specific application to the Highland Valley Copper Project. The report's contents may not be relied upon by any other party without the express written permission of Klohn Crippen Berger. In this report, Klohn Crippen Berger has endeavoured to comply with generally-accepted professional practice common to the local area. Klohn Crippen Berger makes no warranty, express or implied.

KLOHN CRIPPEN BERGER LTD.



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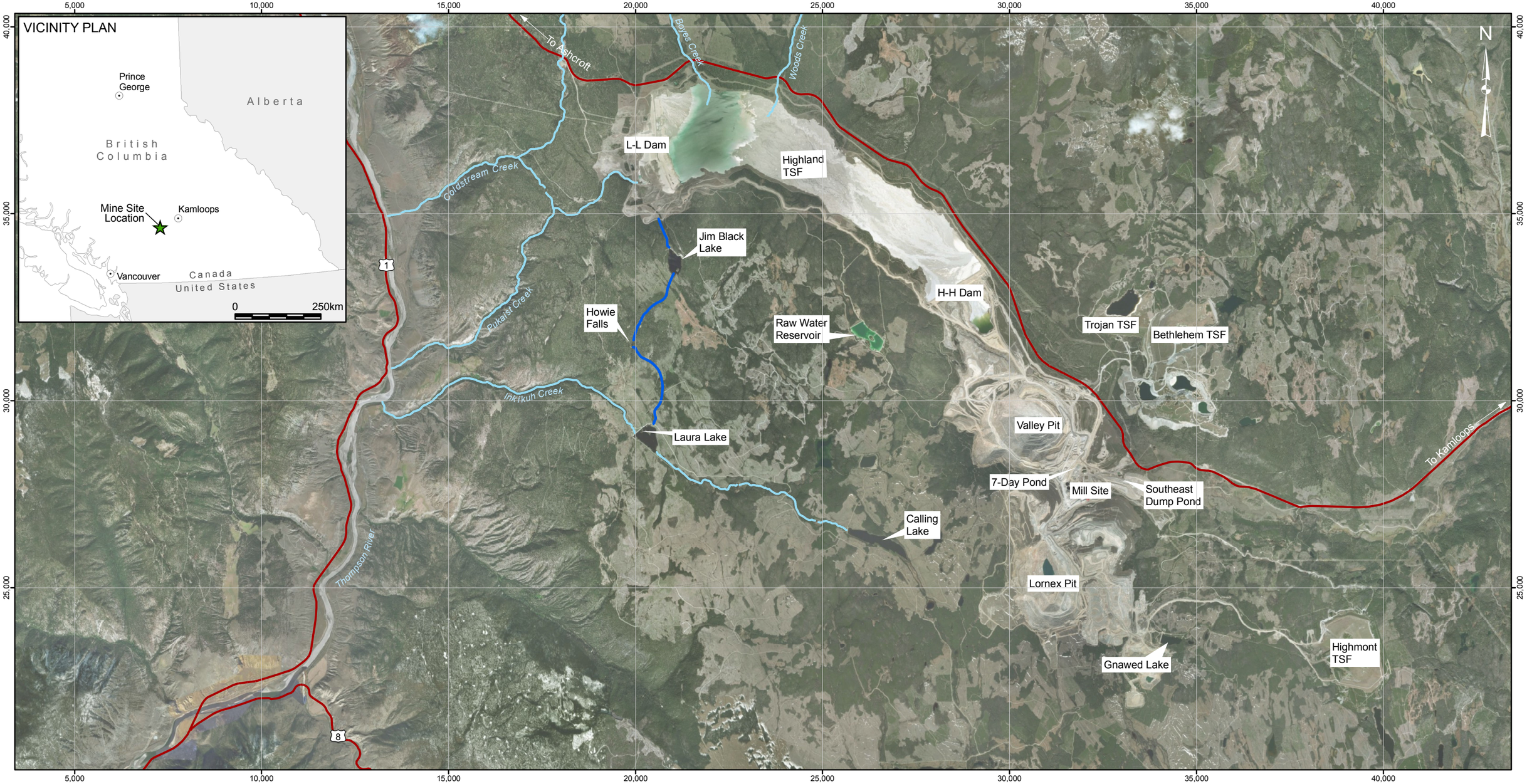
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FIGURES



Legend

- Creek / River
- Highway
- Ditch

0 5km

Notes:
1. Projection: HVC Mine Grid.
2. TSF = Tailings Storage Facility.
3. Base data provided by the Government.
4. Imagery provided by ESRI.

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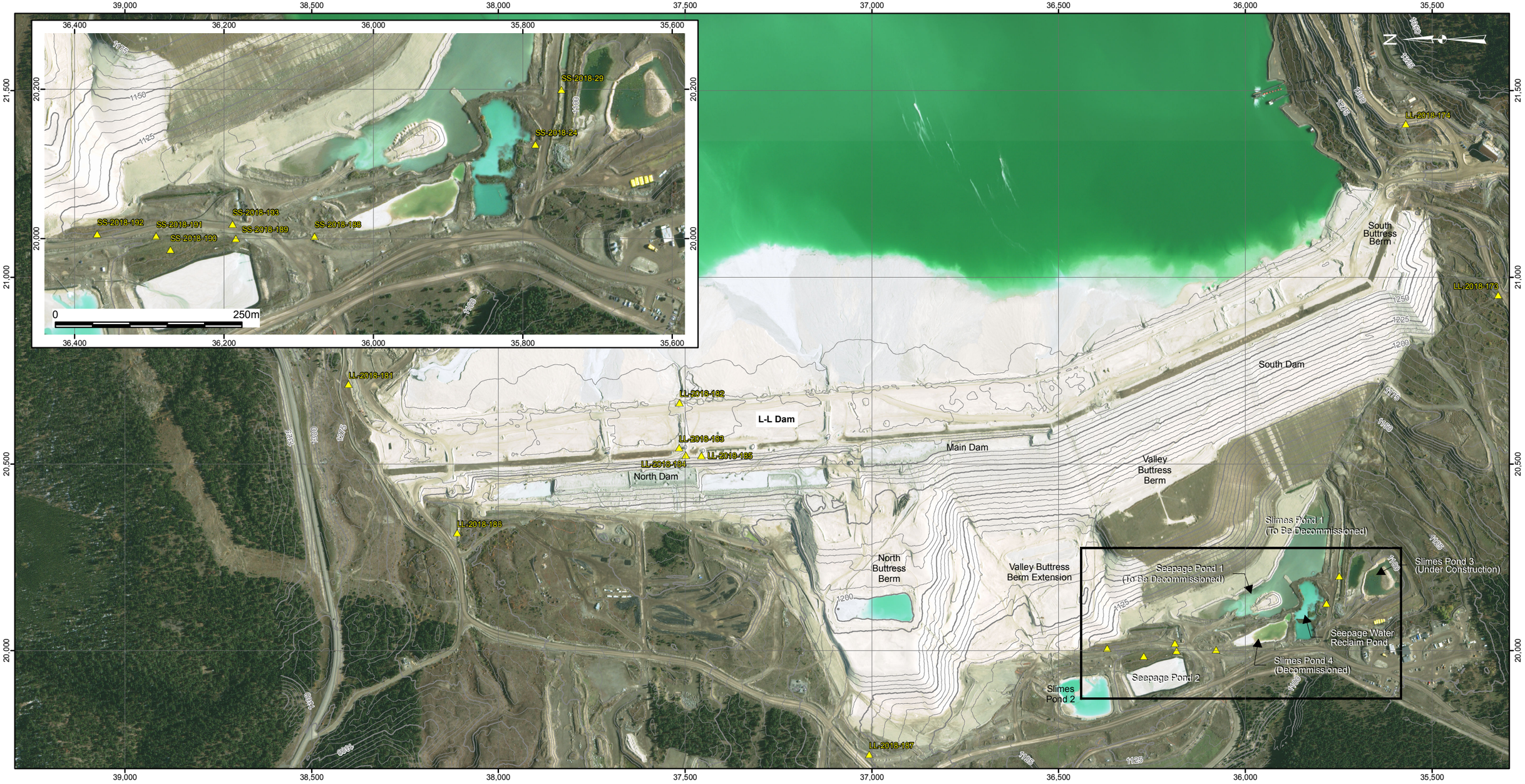
Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

TITLE
MINE SITE PLAN

SCALE	PROJECT No.	FIG No.
1:100,000	M02341B43	1

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Document Path: Z:\MVCR\M02341B43 - HVC 2018 Dam Safety Support\400 Drawings\GIS\02_Maps\Reports\DSI\Highland\Fig1_Highland_MineSitePlan.mxd



Legend

- Waypoint (LL/SS-2018-xx)
- Index Contour (25 m)
- Intermediate Contour (5 m)

Notes:
1. Projection: HVC Mine Grid.
2. Topography from satellite photogrammetry survey conducted in October, 2018.
3. Imagery from October, 2018.

Date: 2019-03-21
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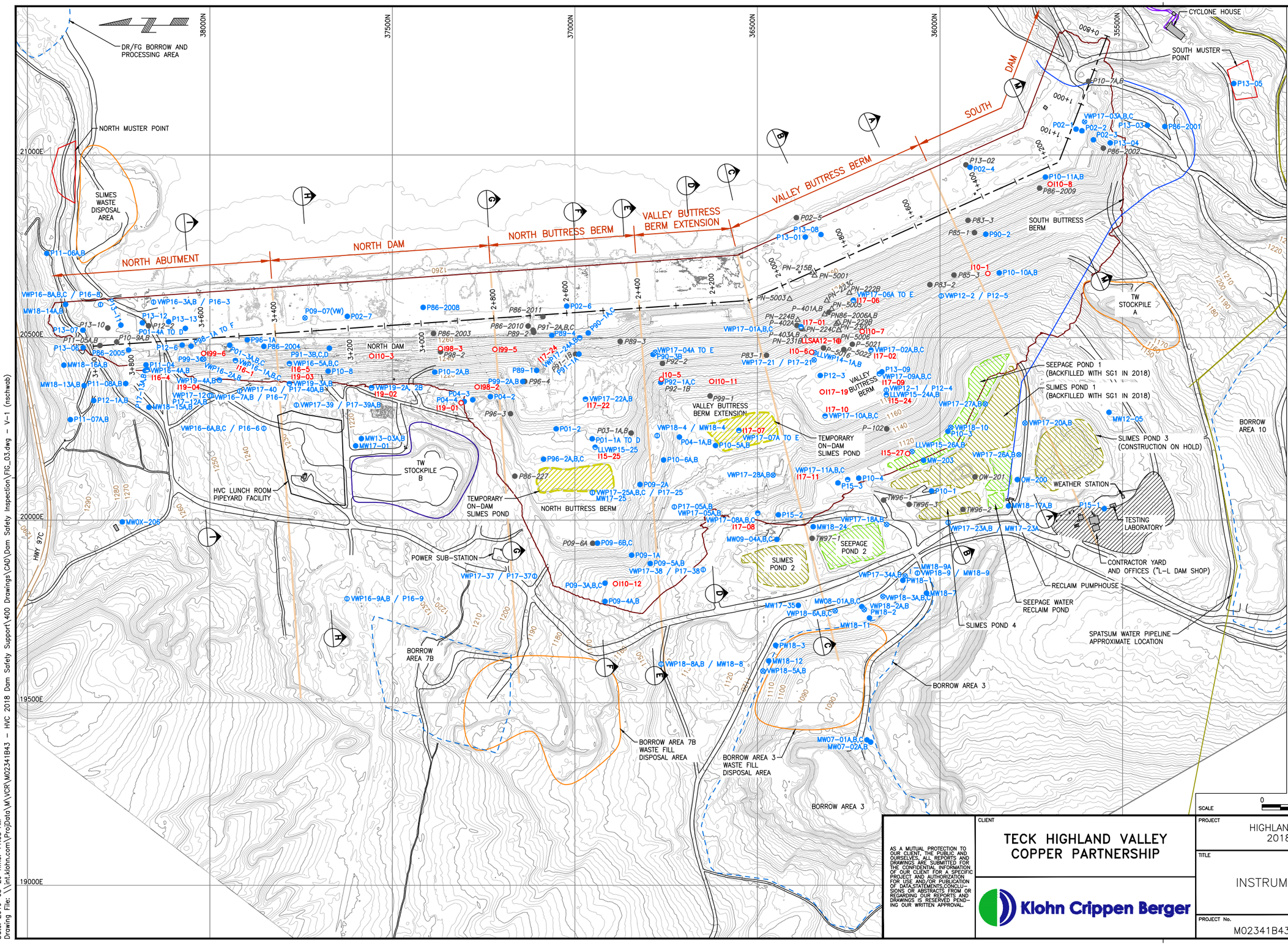
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PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

TITLE: L-L DAM SAFETY INSPECTION WAYPOINTS

SCALE	PROJECT No.	FIG No.
1:10,000	M02341B43	2



LEGEND:

- BORROW AREA
- WASTE FILL DISPOSAL AREA
- SEEPAGE POND
- SLIMES POND
- SLIMES POND (ON-DAM)
- EL. 1279 m ULTIMATE DAM FOOTPRINT
- SURFACE WATER RECLAIM PIPELINE
- SPATSUM WATER PIPELINE
- HAUL ROAD
- PUBLIC ROAD
- L-L DAM CENTERLINE (0+800)
- GEOLOGICAL CROSS SECTION (M)

ACTIVE INSTRUMENTS (SEE NOTE 2):

- STANDPIPE PIEZOMETER AND OBSERVATION WELL
- VIBRATING-WIRE PIEZOMETER
- COMBINED STANDPIPE PIEZOMETER AND VIBRATING-WIRE PIEZOMETER
- COMBINED INCLINOMETER AND VIBRATING-WIRE PIEZOMETER
- STANDARD INCLINOMETER
- IN-PLACE SAA INCLINOMETER

DEFUNCT INSTRUMENTS (SEE NOTE 3):

- DEFUNCT PNEUMATIC PIEZOMETER
- DEFUNCT STANDPIPE PIEZOMETER
- DEFUNCT INCLINOMETER

NOTES:

1. TOPOGRAPHY OF L-L DAM IS GENERALLY BASED ON THE FOLLOWING:
   - AREAS OUTSIDE THE DAM FOOTPRINT ARE BASED ON OCTOBER 2018 PHOTOSAT SURVEY.
   - AREAS OF HYDRAULICALLY PLACED FILLS ARE BASED ON AS-BUILT SURVEYS PROVIDED BY TECK HIGHLAND VALLEY COPPER DATED 2018-12-10 (II-HS-3), 2018-11-14 (I-HS-1), 2018-10-22 (I-HS-2), 2018-12-05 (VBBE) AND 2018-12-17 (I-HS-4).
   - AREAS OF MECHANICALLY PLACED FILLS (SG1, S1 AND S2) AND FOUNDATION EXCAVATIONS (I-E-1, I-E-2, I-A-1, I-A-2, II-E-1, II-E-2, II-E-3) ARE GENERALLY BASED ON AS-BUILT SURVEYS PROVIDED BY NORTH AMERICAN CONSTRUCTION GROUP, DATED 2019-02-06 (COMPILED L-L APPROVED FOUNDATIONS), 2019-02-14 (COMPILED L-L S1 BLANKET), AND 2019-02-13 (COMPILED SG1 BLANKET).
2. ACTIVE INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: CURRENTLY READING AN ACTIVE WATER LEVEL, DRY OR PLUGGED <20 m ABOVE TIP ELEVATION AS THIS COULD SHOW A RESPONSE IN THE FUTURE.
3. DEFUNCT INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: DESTROYED, DAMAGED OR PLUGGED >20 m ABOVE TIP ELEVATION.
4. ASTERISK (*) DENOTES PROPOSED INSTRUMENT LOCATION TO BE UPDATED WITH AS-CONSTRUCTED LOCATION WHEN SURVEY IS COMPLETED.

SCALE 0 250 m

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA,STATEMENTS,CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

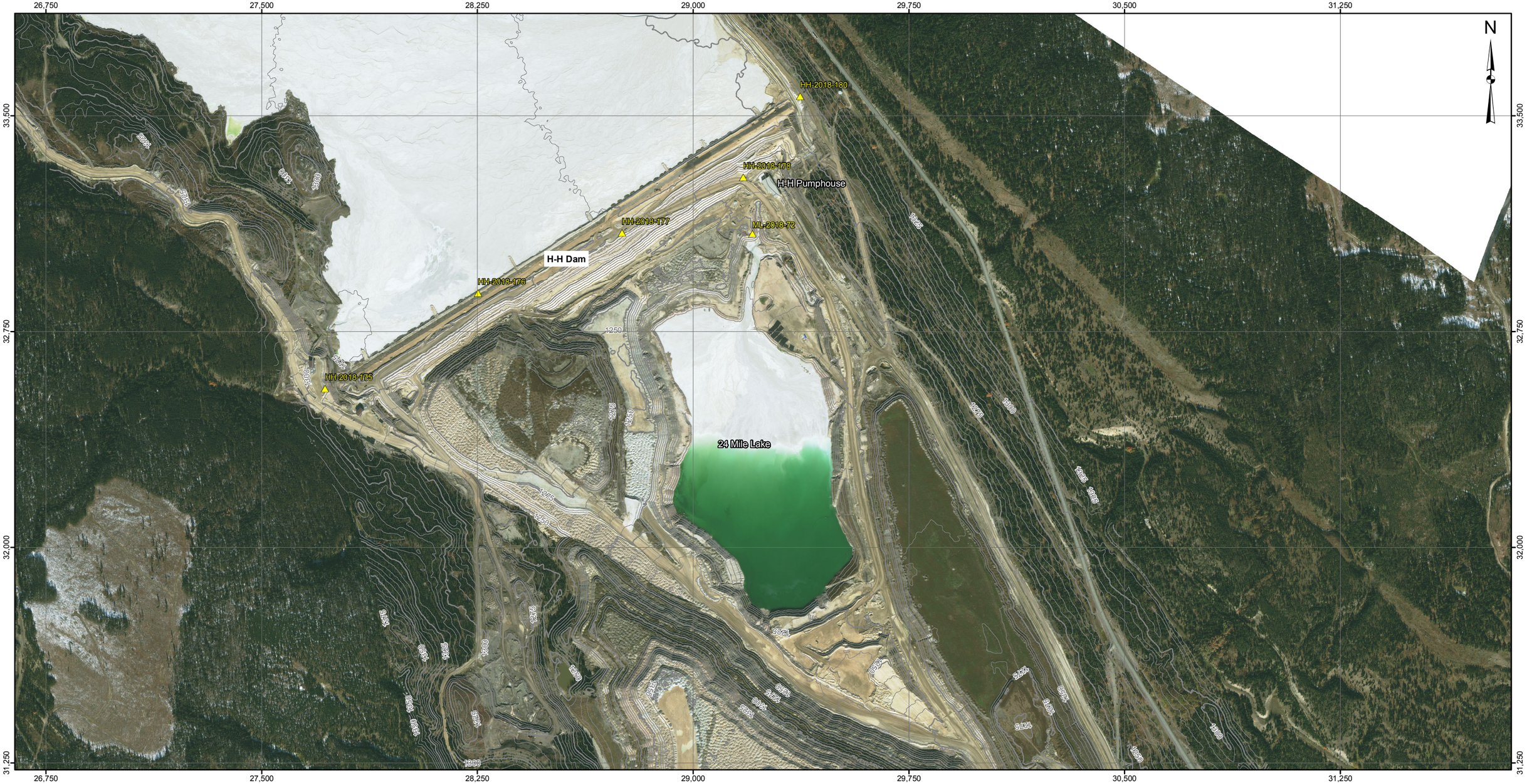
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INSTRUMENTATION LOCATION PLAN

PROJECT No. M02341B43

FIG. No. 3

KCB-R-MLD

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Legend

- Waypoint (HH/ML-2018-xx)
- Index Contour (25 m)
- Intermediate Contour (5 m)

0 500m

Notes:
1. Projection: HVC Mine Grid.
2. Topography from satellite photogrammetry survey conducted in October, 2018.
3. Imagery from October, 2018.

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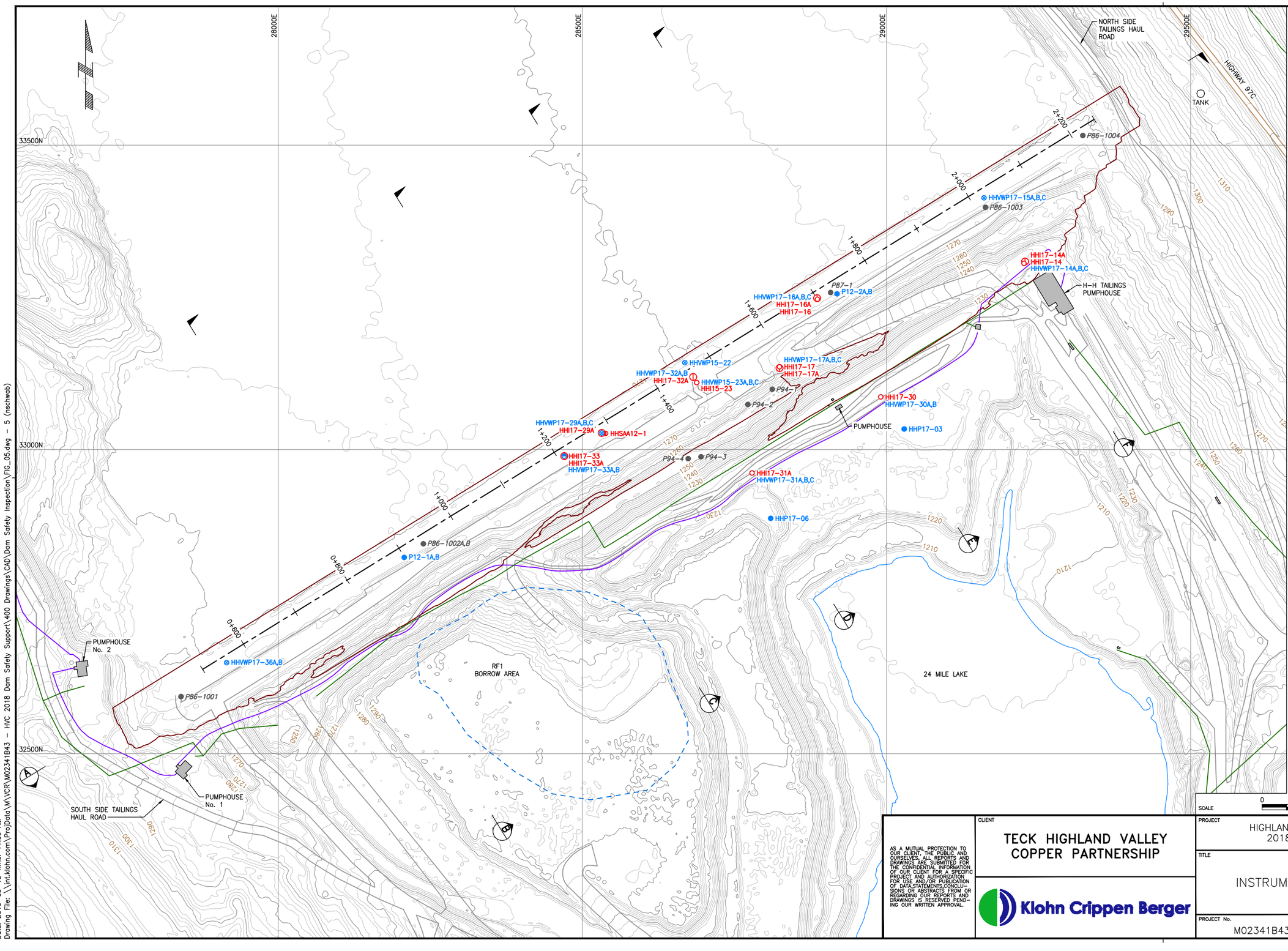
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PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

TITLE
H-H DAM AND 24 MILE LAKE
DAM SAFETY INSPECTION WAYPOINTS

SCALE	PROJECT No.	FIG No.
1:13,000	M02341B43	4

Date: 2019-03-21
Document Path: Z:\MVCR\M02341B43 - HVC 2018 Dam Safety Support\400 Drawings\GIS\02_Maps\Reports\DSI\Highland\Fig4_HH_Dam_DamPlan.mxd



LEGEND:

- BORROW AREA
- ULTIMATE DAM FOOTPRINT
- TAILINGS PIPELINE
- POWERLINE
- HAUL ROAD
- PUBLIC ROAD
- H–H DAM CENTERLINE
- 0+800
- GEOLOGICAL CROSS SECTION

ACTIVE INSTRUMENTS (SEE NOTE 2):

- STANDPIPE PIEZOMETER AND OBSERVATION WELL
- VIBRATING–WIRE PIEZOMETER
- COMBINED STANDPIPE PIEZOMETER AND VIBRATING–WIRE PIEZOMETER
- COMBINED INCLINOMETER AND VIBRATING–WIRE PIEZOMETER
- STANDARD INCLINOMETER
- COMBINED STANDARD INCLINOMETER AND IN–PLACE SAA INCLINOMETER
- COMBINED STANDARD INCLINOMETER AND PAIRED SONDEX SETTLEMENT SYSTEM

DEFUNCT INSTRUMENTS (SEE NOTE 3):

- DEFUNCT STANDPIPE PIEZOMETER
- DEFUNCT COMBINED STANDARD INCLINOMETER AND IN–PLACE SAA INCLINOMETER

NOTES:

1. TOPOGRAPHY PROVIDED BY TECK HIGHLAND VALLEY COPPER PARTNERSHIP AND WAS DERIVED FROM SATELLITE IMAGERY TAKEN ON 2018–10–06 AND 2016–09–25 & 28.
2. ACTIVE INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: CURRENTLY READING AN ACTIVE WATER LEVEL, DRY OR PLUGGED <20 m ABOVE TIP ELEVATION AS THIS COULD SHOW A RESPONSE IN THE FUTURE.
3. DEFUNCT INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: DESTROYED, DAMAGED OR PLUGGED >20 m ABOVE TIP ELEVATION.
4. ASTERISK (*) DENOTES PROPOSED INSTRUMENT LOCATION TO BE UPDATED WITH AS–CONSTRUCTED LOCATION WHEN SURVEY IS COMPLETED.

SCALE 0 200 m

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

TITLE
H–H DAM
INSTRUMENTATION LOCATION PLAN

PROJECT No. M02341B43

FIG. No. 5

KCB–R–MLD

Date: 2019–03–15 Time: 11:00 AM
Drawing File: \\vl.klohn.com\ProjData\M\VCR\M02341B43 – HVC 2018 Dam Safety Support\400 Drawings\CAD\Dam Safety Inspection\FIG_05.dwg – 5 (nschwab)

APPENDIX I

Dam Safety Inspection Checklist

APPENDIX I-A

L-L Dam Safety Inspection Checklist

ANNUAL DAM SAFETY INSPECTION CHECKLIST

Klohn Crippen Berger

Facility:	L-L Dam	**Inspection Date:**	September 11, 2018
Weather:	Sunny	**Inspector(s):**	Bill Chin, P.Eng. Rick Friedel, P.Eng.
Minimum observed freeboard height (pond level to dam crest):	Large freeboard (~8 m to 10 m), visually difficult to estimate (after inspection – survey indicates freeboard was ~9.5 m)		

Are the following components of your dam in *SATISFACTORY CONDITION*? (check one if applicable)

EMBANKMENT	Yes/No
U/S slope	☒ Yes ☐ No
Crest	☒ Yes ☐ No
D/S Slope	☒ Yes ☐ No
D/S Toe	☒ Yes ☐ No

Were any of the following *POTENTIAL PROBLEM INDICATORS* found?

INDICATOR	EMBANKMENT	INDICATOR	EMBANKMENT
Piping	☐ Yes ☒ No	Settlement	☐ Yes ☒ No
Sinkholes	☐ Yes ☒ No	Sloughing/Slides	☐ Yes ☒ No
Seepage	☐ Yes ☒ No	Animal Activity	☐ Yes ☒ No
External Erosion	☐ Yes ☒ No	Excessive Growth	☐ Yes ☒ No
Cracks	☐ Yes ☒ No	Excessive Debris	☐ Yes ☒ No

List and describe any deficiencies (all deficiencies require assessment and/or repair):

- No dam safety deficiencies observed

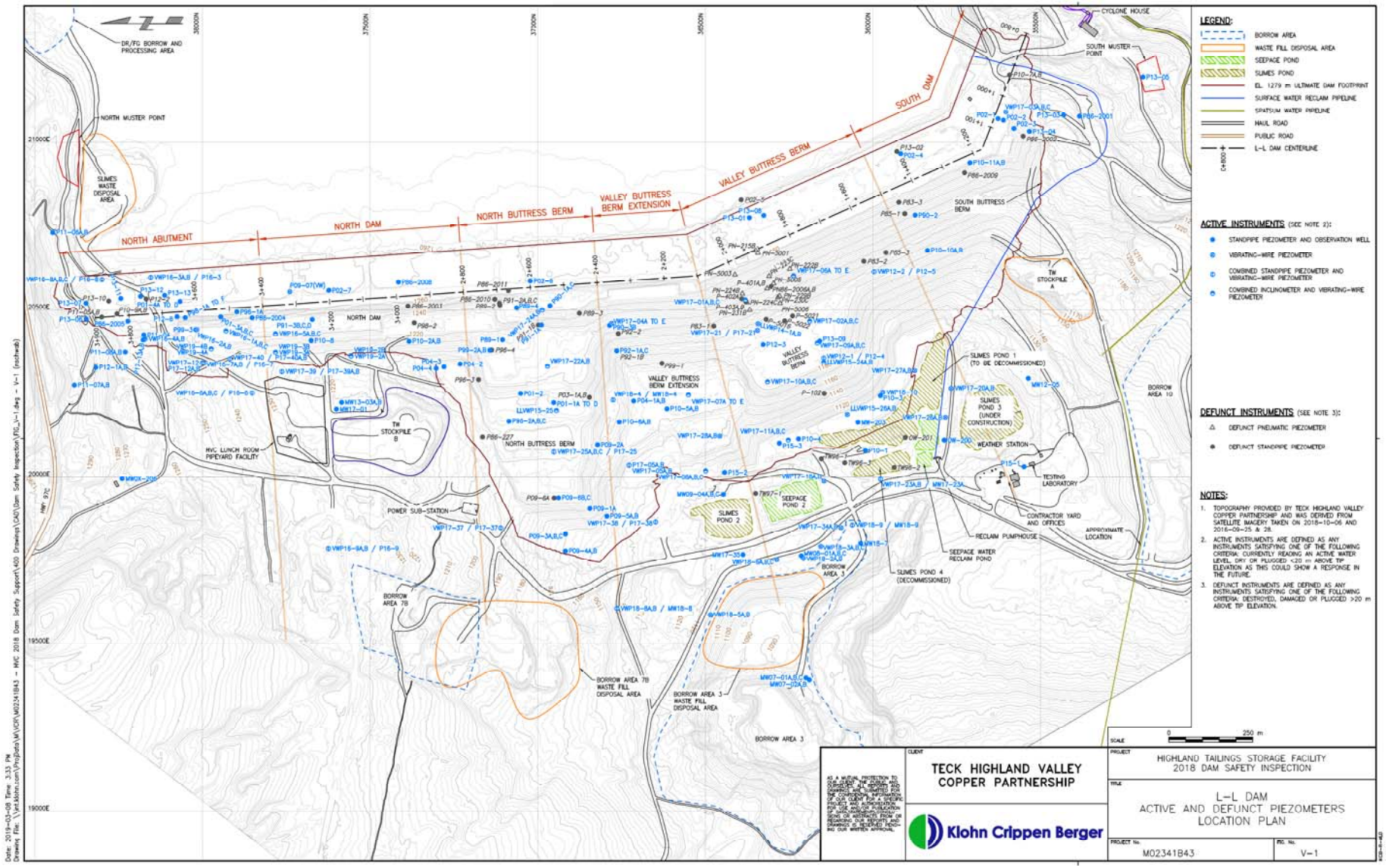
New and Outstanding deficiencies:

- No dam safety deficiencies observed

Comments / Notes:

- *Additional discussion of site trip observations in Section 6 of 2018 Dam Safety Inspection report*
- Ongoing cycloned sand construction going on along downstream slope of North Dam. Cells observed in various states (prep, active, draining). One cell is inactive with ponding water, Contractor advised the area will need to be reworked to disturb any settled fines.
- Temporary on-dam slimes cells: VBBE – no ponding, drained; NBB – active, ponded water but no issues of concern
- Downstream ponds: slimes ponds near capacity; adequate freeboard and no issues of concern
- Dam crest: Some slumping / erosion along upstream edge of cycloned sand. Maintenance and worker safety issue, not dam safety concern. Area is intentionally overbuilt to account for slumping.

Figure 1 - SITE PLAN – ***Refer to Figure 2 of 2018 Dam Safety Inspection Report for waypoint locations***



Relevant photos – ***Refer to Appendix II-A of 2018 Dam Safety Inspection Report***

APPENDIX I-B

H-H Dam Safety Inspection Checklist

ANNUAL DAM SAFETY INSPECTION CHECKLIST

Klohn Crippen Berger

Facility:	H-H Dam	**Inspection Date:**	September 11, 2018
Weather:	Sunny	**Inspector(s):**	Bill Chin, P.Eng. Rick Friedel, P.Eng.
Minimum observed buffer height (delta level to dam crest):	Variable along dam crest (>1 m) with most buffer near mid section where beach is lowest.		

Are the following components of your dam in *SATISFACTORY CONDITION*? (check one if applicable)

EMBANKMENT	Yes/No
U/S slope	☒ Yes ☐ No
Crest	☒ Yes ☐ No
D/S Slope	☒ Yes ☐ No
D/S Toe	☒ Yes ☐ No

Were any of the following *POTENTIAL PROBLEM INDICATORS* found?

INDICATOR	EMBANKMENT	INDICATOR	EMBANKMENT
Piping	☐ Yes ☒ No	Settlement	☐ Yes ☒ No
Sinkholes	☐ Yes ☒ No	Sloughing/Slides	☐ Yes ☒ No
Seepage	☐ Yes ☒ No	Animal Activity	☐ Yes ☒ No
External Erosion	☐ Yes ☒ No	Excessive Growth	☐ Yes ☒ No
Cracks	☐ Yes ☒ No	Excessive Debris	☐ Yes ☒ No

List and describe any deficiencies (all deficiencies require assessment and/or repair):

- No dam safety deficiencies observed

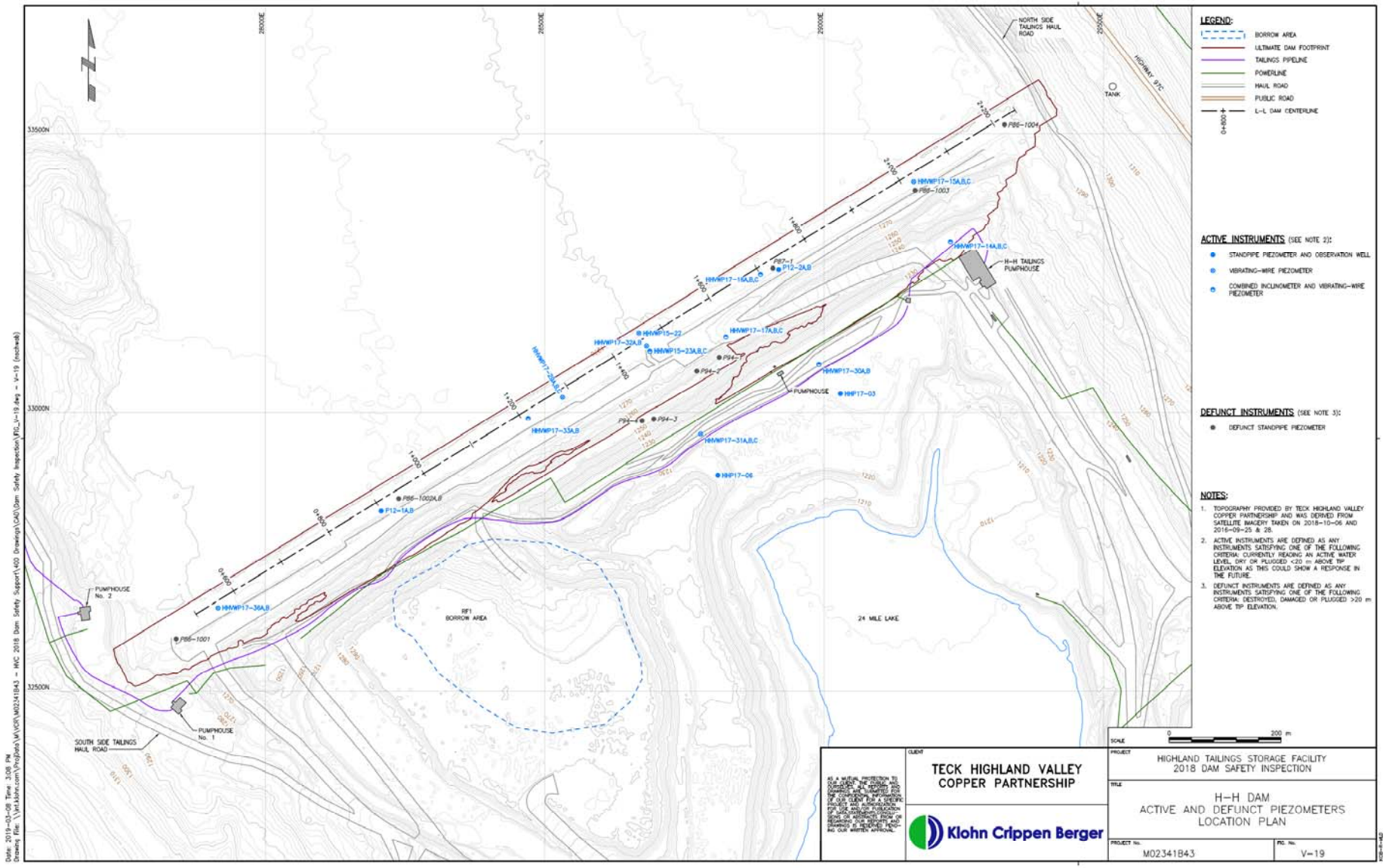
New and Outstanding deficiencies:

- No dam safety deficiencies observed

Comments / Notes:

- *Additional discussion of site trip observations in Section 6 of 2018 Dam Safety Inspection report*
- Construction is ongoing, started recently, and till core has been raised in some locations but not yet near target raise elevation.
- I-7 Dump was raised long the southside of 24 Mile Lake. Waste did not encroach on H-H Dam fill and no observed impact on dam safety.
- No issues of cracking or slumping observed in downstream rockfill
- Beach dry in front of dam fill, deposition point is upstream of the main tailings cone on east abutment so no deposition near dam slope.

Figure 1 - SITE PLAN – ***Refer to Figure 4 of 2018 Dam Safety Inspection Report for waypoint locations***



Relevant photos – ***Refer to Appendix II-B of 2018 Dam Safety Inspection Report***

APPENDIX II

Inspection Photographs

APPENDIX II-A

L-L Dam Inspection Photographs

Appendix II-A
Inspection Photographs - L-L Dam

LEGEND:

- LL = L-L Dam.
- LL-2018-## refers to 2018 DSI waypoint shown on Figure 2.
- All photographs taken during inspection on September 11, 2018.

Photo II-A-1 Overview of southern downstream slope and ponds. No signs of erosion were visible (LL-2018-173)



Photo II-A-2 Beach Crest and Tailings Pond near South Abutment (LL-2018-174)



Photo II-A-3 Foundation Spoils Dump and Beach from North Side of Impoundment Upstream of L-L Dam. (LL-2018-181)



Photo II-A-4 North Abutment Discharge Points - No signs of erosion on upstream slopes was observed. Freeboard was observed. (LL-2018-181)



Photo II-A-5 Upstream Dam Face – Local Undercutting at Beach Face near Spigot Point. Erosion is Restricted to Overbuilt Portion of Upstream Sand Zone. Location, Facing South – Beach was Constructed using Hydraulic Sand Panels in 2015 (LL-2018-182)



Photo II-A-6 Typical Dam Crest and Sand Zone. No Signs of Undercutting on Major Scour in Dam Fill (LL-2018-182)



Photo II-A-7 Secondary Cyclone Cluster Set on dam Crest for Downstream Hydraulic Sand Placement. (LL-2018-183)



Photo II-A-8 Dam Crest showing Till Core Zone (grey) and Upstream (left of grey) and Downstream (right of grey) Sand Zones. (LL-2018-183)



Photo II-A-9 Overview of North Dam Downstream Slope and NBB, Facing Southeast. North Dam Hydraulic Sand Panels are Visible as is NBB Temporary Slimes Cell (LL-2018-184)



Photo II-A-10 Overview of North Dam Downstream Slope, Facing Northeast. North Dam Hydraulic sand panels are visible in panel indication of settling fines following an unscheduled shutdown of placement in cell. Area is reworked when placement resumes. Shutdown in the feed (LL-2018-184)



Photo II-A-11 Overview of NBB and Temporary ON-dam Slimes Storage Cell, Facing Southeast. No signs of instability or seepage along downstream slopes were noted during cell operation. (LL-2018-184)



Photo II-A-12 Overview of North Dam Downstream Slope. (LL-2018-186)



Photo II-A-13 Typical Prepared Hydraulic Sand Panel Prior to Placement. (LL-2018-184)



Photo II-A-14 Downstream Collection Ponds with Slimes Storage. (LL-2018-187)



Photo II-A-15 Downstream Slope looking from NBB to Smith Dam. (LL-2018-187)



Photo II-C-16 VBB (with till cover) and South dam and VBBE Downstream Slopes. (LL-2018-191)







APPENDIX II-B

H-H Dam Inspection Photographs

Appendix II-B
Inspection Photographs - H-H Dam

LEGEND:

- HH = H-H Dam.
- HH-2018-## refers to 2018 DSI waypoint shown on Figure 4.
- All photographs taken during inspection on September 11, 2018.

Photo II-B-1 Overview of H-H Dam from West Abutment with Fill Zones Noted. (HH-2018-175)



Photo II-B-2 Overview of West Abutment and Exposed Bedrock Abutment Foundation. (HH-2018-175)



Photo II-B-3 H-H Dam beach and upstream crest – facing west and east abutments (HH-2018-176)







Photo II-B-4 Dam Crest Facing West and East Abutments. Crest has no visible depressions and shows no signs of differential movement. Rockfill riprap on the upstream slope is intact and shows no signs of degradation or erosion (HH-2018-176)



Photo II-B-5 View of Downstream Slope Form Crest – facing south and southeast. Slopes show no signs of significant erosion. (HH-2018-177)



Photo II-B-6 I-9 Dump Fill Places in 2018 Downstream of H-H Dam. (HH-2018-177)



Photo II-B-7 East Abutment – facing northeast; technicians reading the instruments behind the H-H pumphouse retaining wall (HH-2018-178)



Photo II-B-8 Downstream Slope of Dam – facing west (HH-2018-178)



Photo II-B-9 **Downstream Slope near East Abutment. Crest has no visible depressions and shows no sign of differential movement. Rockfill downstream slope is in good condition without any signs of degradation or erosion. H-H pumphouse pipes are visible in this photo (HH-2018-178)**



Photo II-B-10 **Dam Crest from East Abutment. Photos showing beach and construction activities (HH-2018-180)**

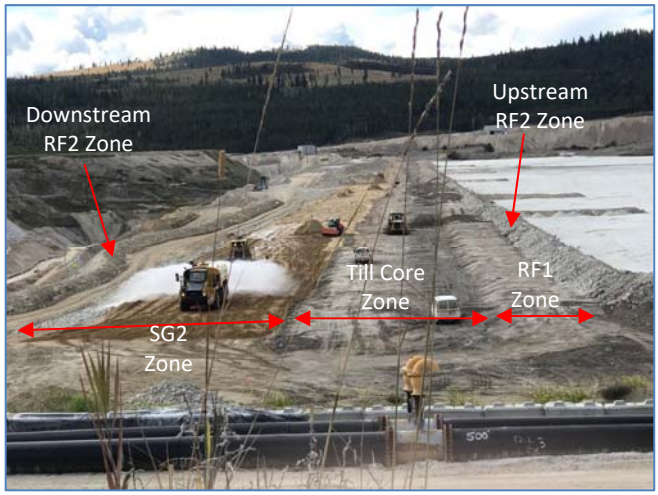




Photo II-B-11 H-H Pumphouse outflow channel, facing south (ML-2018-72)



Photo II-B-12 Southwest Side of 24 Mile Lake – >10 m freeboard observed Some surface erosion gullies in waste dump slope but do not pose in the 24 Mile Lake integrity.



Photo II-B-13 Photo II-D-14 H-H Pumphouse Emergency Dump Outflow Pipes, and Upstream Channel Facing North – an erosion gully is visible on the right slope (ML-2018-72)



APPENDIX II-C

L-L Dam Seepage Slimes Ponds Inspection Photographs

Appendix II-C
Inspection Photographs - L-L Dam Seepage and Slimes Pond

LEGEND:

- SS = L-L Dam seepage and slimes ponds.
- SS-2018-## refers to 2018 DSI waypoint shown on Figure 2.
- All photographs taken during inspection on July 16, 2018.

Photo II-C-1 Seepage Water Reclaim Pond (SWRP) Overview (SS-2018-24)



Photo II-C-2 SWRP – culvert from Jim Black Lake (JBL) diversion is blocked. (SS-2018-24)



Photo II-C-3 Jim Black Lake Diversion Channel Toe for Discharging into SWRD. (SS-2018-29)



Photo II-C-4 Overview of Slimes Pond 4 (SS-2018-188)

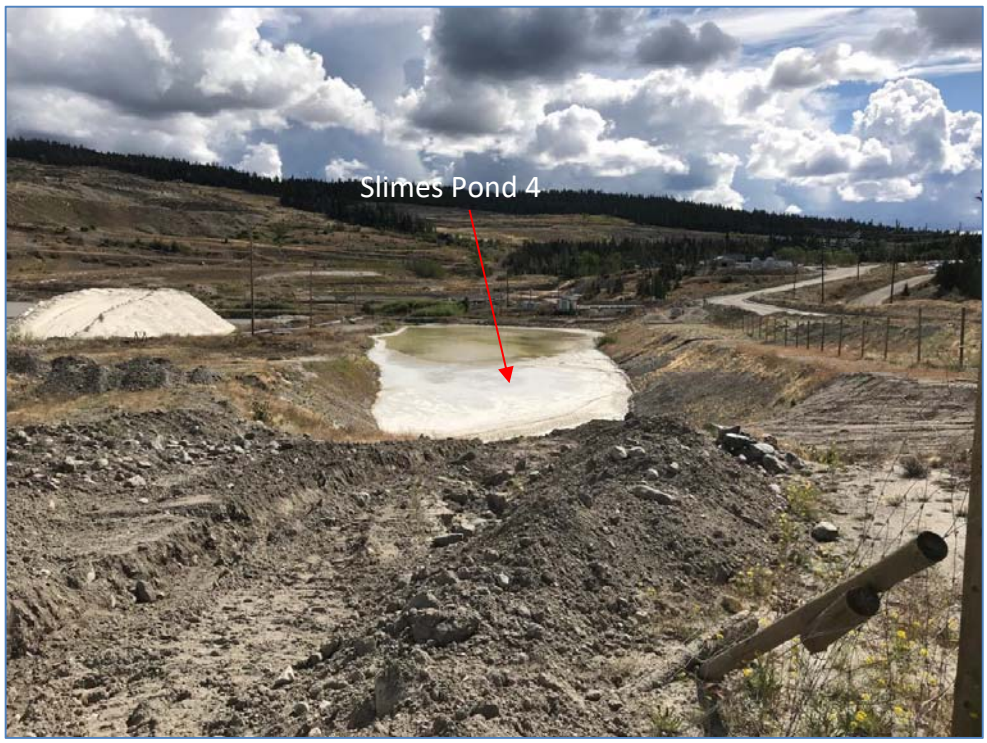


Photo II-C-5 Seepage Pond 2 Lock-block Wall. Pond used for slimes storage in 2018. (SS-2018-189)



Photo II-C-6 Seepage Pond 2 Inflow from Slimes Pond 2. Pond used for slimes storage in 2018. (SS-2018-190)



Photo II-C-7 Overview of Seepage Pond 1 Area which was Backfilled in 2018 as part of dam Foundation Prep. (SS-2018-192)



Photo II-C-8 Seepage Pond 2 Outfall and Weir. (SS-2018-193)



Photo II-C-9 Overview of Slimes Pond 1 which was Decommissioned in 2018 by Removal Slimes and Backfilling with Compacted Fill. Seepage Pond 1 Backfill also Visible along Dam Toe (LL-2018-173)



APPENDIX III

Reference Dam Design Drawings

Appendix III
Design Drawings

III-A – L-L Dam

L-L Dam overview and history summary text.

Design drawings are taken from the following report:

- Klohn Crippen Berger. 2010. "Tailings Storage Facility - Ultimate Dam Crest Elevation for 2028 Mine Plan", August 20.

List of drawings -

- Figure 4 L-L Dam General Arrangement Ultimate Dam
- Figure 9 L-L Ultimate Dam Station 1+160
- Figure 10 L-L Ultimate Dam Station 1+600
- Figure 11 L-L Ultimate Dam Station 2+000
- Figure 12 L-L Ultimate Dam Station 2+200
- Figure 13 L-L Ultimate Dam Station 2+550
- Figure 14 L-L Ultimate Dam Station 2+900
- Figure 15 L-L Ultimate Dam Station 3+200
- Figure 17 Ultimate Dam Spillway, LLO and Drainage Ditches Preliminary Arrangement – Plan
- Figure 18 Ultimate Dam Spillway and LLO Preliminary Profiles & Typ. Sections

III-B – H-H Dam

H-H Dam overview and history summary text.

Design drawings are taken from the following report:

- Klohn Crippen Berger. 2010. "Tailings Storage Facility - Ultimate Dam Crest Elevation for 2028 Mine Plan", August 20.

List of drawings -

- Figure 5 H-H Dam General Arrangement Ultimate Dam
- Figure 16 H-H Ultimate Dam Station 1+500

III-C – L-L Dam Seepage and Slimes Ponds

C-1 – Seepage Pond 1

No design drawings available

C-2 - Seepage Pond 2

- THVCP Drawing 1011-021-SlimePond-ASB.dwg “Slimes Pond Plan and Sections”, September 2012 (as-built)
- THVCP Drawing “Seepage Pond #2 Ditch Design”, February 2014

C-3 – Slimes Pond 1

No design drawings available

C-4 – Slimes Pond 2

- Drawing No. D-74001 “Slimes Pond 2 Earthworks Plan”, Oct 2014.
- Drawing No. D-74002 “Slimes Pond 2 Cross Sections and Liner Details”, Oct 2014.
- Drawing No. D-74003 “Slimes Pond 2 Outflow Pipe and Underdrain Sump Details”, Oct 2014.
- Drawing No. D-74004 “Slimes Pond 2 Fill and Placement Specifications”, Oct 2014.

C-5 – Seepage Water Reclaim Pond

- Drawing 111-803-140 Rev 1 “Water Collection Dam L-L Axis Plan and Sections” 1977

III-C – 24 Mile Lake

No design drawings available

APPENDIX III-A

L-L Dam

Appendix III-A
L-L Dam Overview

I-1 STRUCTURE OVERVIEW

The layout of the L-L Dam and associated structures is shown in Figure 2 of the main text. For context and reference, selected design drawings and typical cross sections attached to this appendix. As of the end of 2018, the crest elevation of L-L Dam is 1262.5 m, corresponding to a maximum downstream slope height (crest to toe of Valley Buttress Berm at El. 1105 m) of about 157.5 m. The currently permitted ultimate crest of the L-L Dam is El. 1279 m, which corresponds to a maximum height of 174 m at the same location. References made throughout this document refer to those listed in main text.

The L-L Starter Dam, has a low permeability glacial till core zone supported by zoned earthfill on the upstream and downstream sides. All fill materials were sourced from nearby borrows. There is an upstream glacial till blanket and cut-off trench which are connected to the core. A drainage blanket is present downstream of the glacial till core zone to maintain low piezometric pressures in the downstream dam shell.

The starter dam was raised via the centerline method with a 15.2 m wide glacial till core zone extended vertically above the starter dam. The core zone of the raises is supported by a downstream zone of hydraulically placed, compacted cycloned sand and an upstream compacted cycloned sand berm (above El. 1222 m) and tailings beach (below El. 1222 m), Figure 6.

Prior to fill placement, the foundation of the downstream shell is stripped of unsuitable material down to competent foundation, typically glacial till or bedrock. The lacustrine deposit present underneath the starter dam has been removed from the footprint of the downstream cycloned sand shell.

The prepared foundation is covered with a sand and gravel blanket drain (1.5 m minimum design thickness). A network of minor and major underdrains is excavated into the blanket drain to increase drainage capacity and maintain a low phreatic level in the downstream dam shell. In addition to seepage flows, the underdrainage system must also have sufficient capacity to drain construction related seepage from the hydraulic placement cells with no sustained build up of water in the cycloned sand fill.

Cycloned sand fill to date has been placed hydraulically in cells where compaction is achieved by a combination of downward seepage forces, vibration and load from the tracked bulldozer which is used to distribute the sand throughout the cell during placement.

An upstream compacted cycloned sand zone, 126 m (min.) wide, is present above El. 1222 m. The L-L Dam has been designed assuming the pond is adjacent to the upstream sand zone. However, tailings are spigotted from the crest of the upstream sand zone to form a beach between the dam and the tailings pond where possible.

Foundation materials govern structural integrity of the L-L Dam rather than the dam fill. The L-L Dam is divided in five design segments (Figure 2 of main text) based on foundation conditions as summarized herein:

South Dam – Sta. 0+800 (South Abutment) to Sta. 1+600:

- Foundation mainly comprises competent glacial till overlying granodiorite bedrock.

Valley Buttress Berm (VBB) – Sta. 1+600 to Sta. 2+100:

- Foundation mainly comprises thick (90 m) sequence of glacial deposits with continuous layers of glaciolacustrine deposits. The Upper-Glaciolacustrine Unit and Lacustrine Unit, were removed downstream of the starter dam during foundation preparation.

Valley Buttress Berm Extension (VBBE) – Sta. 2+100 to Sta. 2+400:

- Foundation transitions between the VBB and NBB as the thickness of glacial deposits reduces to the north, discontinuous layers of glaciolacustrine deposits are present and govern stability.

North Buttress Berm (NBB) – Sta. 2+400 to Sta. 2+800:

- Foundation mainly comprises mixed bedrock at surface or shallow depth, between volcanic and sedimentary units of the Kamloops Group, sedimentary bedrock includes mudstone sequences.

North Dam – Sta. 2+800 to Sta. 3+900 (North Abutment):

- Foundation mainly comprises glacial deposits, the depth to bedrock increase to the north. Lenses and a continuous layer of glaciolacustrine are present which was been excavated from some areas of the foundation, where practical, during 2018 foundation preparation.

The overall downstream slope of the L-L Dam, measured from downstream edge of crest and downstream toe, is 2.5H:1V except for segments where foundation conditions govern the need for additional buttressing to meet stability criteria (i.e., VBB, VBBE, NBB). KCB (2018d) includes a more comprehensive summary of the geology and foundation characterization of the L-L Dam.

I-2 HISTORICAL OVERVIEW

A brief history of the construction and operations at the L-L Dam is summarized below. This information was based on the construction summary reports prepared from 1978 to 2015:

- The starter dam was constructed to El. 1155 m between 1976 and 1979 (Bechtel 1977, KL 1988). Since then, the dam has been raised on a regular basis (typically annually).
- The first major redesign occurred with the excavation and replacement of the downstream lacustrine deposits followed by the extension of the VBB during construction of the starter dam in 1978 (KL, 1988).

- The Seepage Water Reclaim Pond was constructed in the 1980's.
- Slimes Pond 1 and Seepage Pond 1 were constructed in the early 1990's.
- The South Buttress Berm (SBB), was added to the design in 1995 to support an upstream bend in the dam alignment (KC 1995).
- In 1992, the initial stages of the North Buttress Berm (NBB) were constructed and design was modified based on observed performance to control foundation movements in the weaker sedimentary layers in the underlying bedrock (KL 1992, KC 1999, KCB 2018d).
- An upstream compacted cycloned sand zone was added to the design and initially constructed in 2000 (KC 2000) to allow for steeper upstream dam slopes to facilitate the closure configuration at the time. When the mine life was extended, and ultimate crest raised, the upstream cycloned sand section was continued to meet upstream stability criteria (KC 2003).
- In 2001, a Low-Level Outlet (LLO) was constructed at the south abutment of the dam (KCB 2014a). In addition, the upstream compacted cycloned sand zone was incorporated into the design.
- Seepage Pond 2 was constructed in 2012 (KCB 2013).
- The LLO was decommissioned by backfilling with concrete (KCB 2014a) in 2013, and in 2015 an inverted filter drain was constructed at the outlet of the decommissioned LLO to mitigate piping risks (KCB 2015).
- In 2013, the pumps in Seepage Pond 1, which controlled outflow to the Seepage Water Reclaim Pond, were removed and replaced by the installation of a gravity outlet pipe at the south end of the pond (KCB 2014b).
- The north side tailings pipeline and Cyclone House were decommissioned in 2013 as the cyclone house was becoming inundated by rising tailings level. The replacement South Side Tailings System (SSTS) and south side Cyclone House was commissioned in 2014.
- In 2014, construction of the Valley Buttress Berm Extension (VBBE) commenced, which connects the NBB to the VBB.
- Slimes Pond 2 and Slimes Pond 4 were constructed in 2014. In 2015, Slimes Pond 3 construction commenced but is not yet complete (KCB 2016b).
- There was no construction at the L-L Dam in 2015 or 2016. Construction resumed in 2017 and the dam raise (to El. 1262.5 m) was completed in 2018. KCB (2019) summarizes construction activity and includes record drawings.

DISPOSAL AREA
WASTE / SLIMES

APPROX. LOCATION OF
FUTURE CYCLONE HOUSE

CONCEPTUAL SPILLWAY AND LOW
LEVEL OUTLET SHOWN ON FIGURE 17

BORROW
AREA 10C

BEACH

SOUTH BUTTRESS BERM
EL 1261.9m

UPSTREAM BERM
EL 1276.9m

DAM CREST
EL 1279m

5:1 SLOPE

MIN 250 m

25m ± EL. 1198.1m BERM

2.5H:1V

NORTH
BUTTRESS
BERM
EL 1251.6m

VALLEY
BUTTRESS
BERM

EL 1198.1m

EL 1229.1m

3H:1V

2H:1V

TRANSITION

ULTIMATE DAM
TOE LINE

NEW SEEPAGE
COLLECTION POND
(APPROXIMATE)

KLOHN CRIPPEN
BERGER BUILDING

CANTEX
SHOP AREA

BORROW
AREA 10A

POWER
SUB-STATION

BORROW
AREA 7A

BORROW
AREA 7B

HIGHWAY 16

NOTES
1. LOCATION OF SLIME POND TO BE DETERMINED.

SCALE 0 200m

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CLIENT
TECK HIGHLAND VALLEY
COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L-L DAM CREST EL 1279m

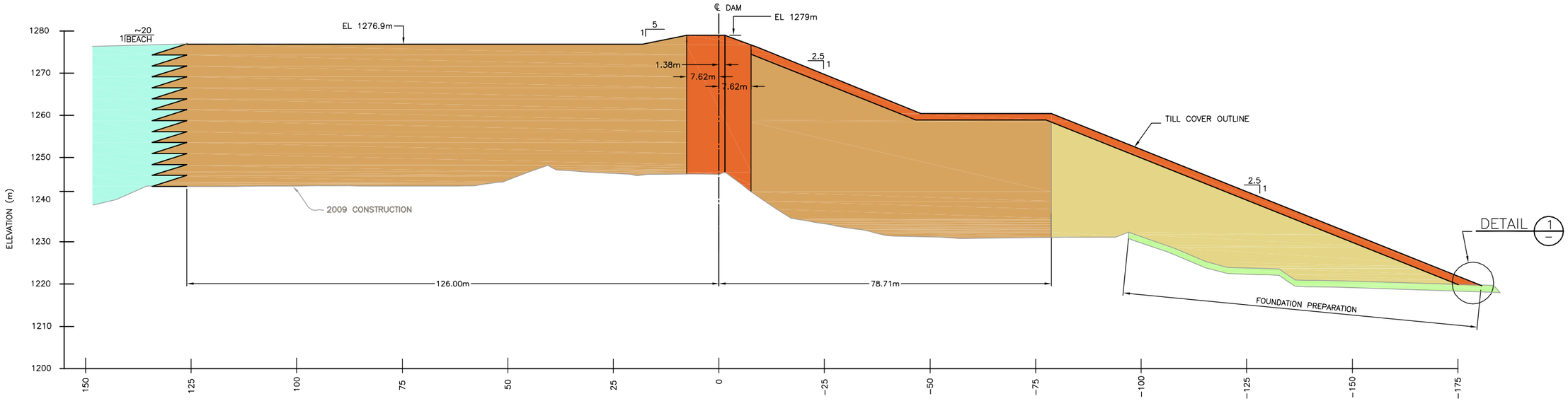
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L-L DAM
GENERAL ARRANGEMENT
ULTIMATE DAM

PROJECT No. M02341A50

FIG. No. 4

K2B-R-MLD

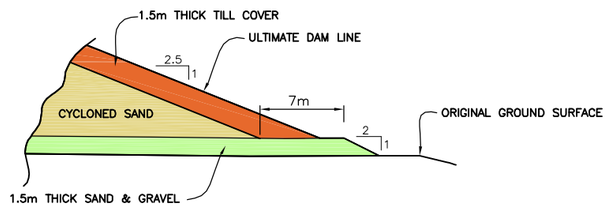
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Xrefs: 2010Piezosimplifiedr1



SECTION TAKEN AT STN. 1+160

TYPICAL SECTION – STN. 1+110 TO STN. 1+220

SECTION A (FIG 4)



DETAIL 1 (–)
SCALE 1:500

LEGEND

- BEACH TAILINGS
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 20%
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 10%
- COMPACTED GLACIAL TILL
- SAND AND GRAVEL

SCALE 0 50m

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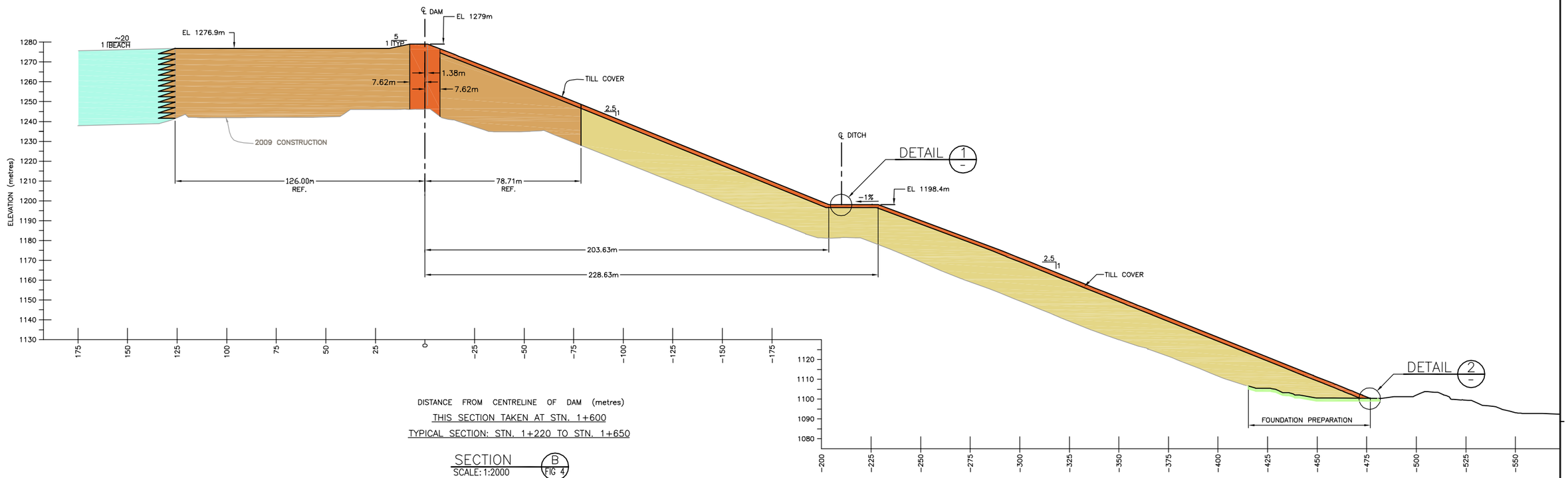
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DESIGN UPDATE FOR L-L DAM CREST EL 1279m

TITLE: L-L ULTIMATE DAM
STATION 1+160

PROJECT No. M02341A50

FIG. No. 9

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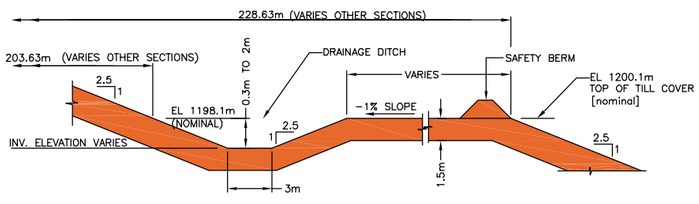


DISTANCE FROM CENTRELINE OF DAM (metres)

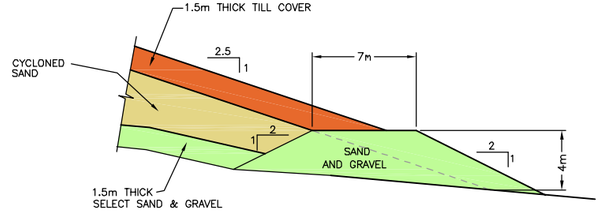
THIS SECTION TAKEN AT STN. 1+600

TYPICAL SECTION: STN. 1+220 TO STN. 1+650

SECTION B
SCALE: 1:2000 FIG 4



DETAIL 1
SCALE: 1:400



DETAIL 2
SCALE: 1:400

LEGEND

- BEACH TAILINGS
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 20%
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 10%
- COMPACTED GLACIAL TILL
- SAND AND GRAVEL

SCALE 0 50 m

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DESIGN UPDATE FOR L-L DAM CREST EL 1279m

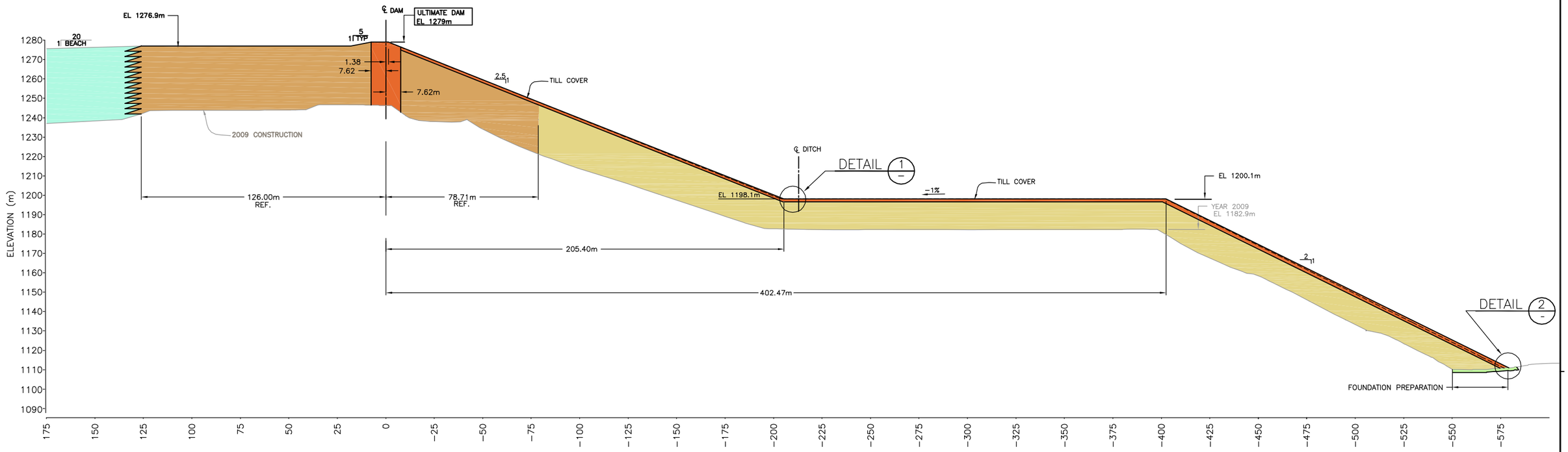
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STATION 1+600

PROJECT No. M02341A50

FIG. No. 10

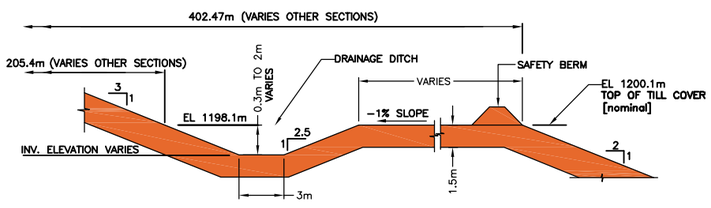
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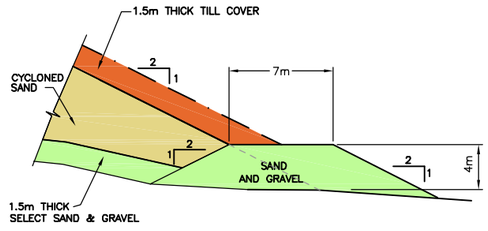


THIS SECTION TAKEN AT STN. 2+000
TYPICAL SECTION: STN. 1+650 TO 2+100

SECTION C (FIG 4)
SCALE 1:2000



DETAIL 1
SCALE 1:400



DETAIL 2
SCALE 1:400

LEGEND

- BEACH TAILINGS
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 20%
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 10%
- COMPACTED GLACIAL TILL
- SAND AND GRAVEL

0 50 m
SCALE

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PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L-L DAM CREST EL 1279m

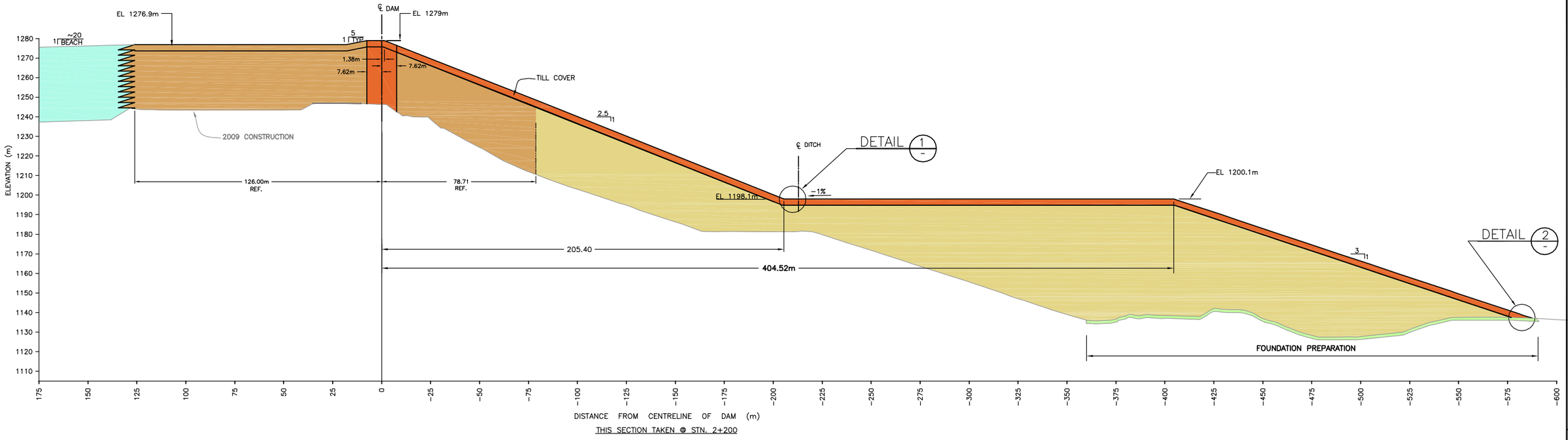
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STATION 2+000

PROJECT No. M02341A50

FIG. No. 11

KCB-3-MED

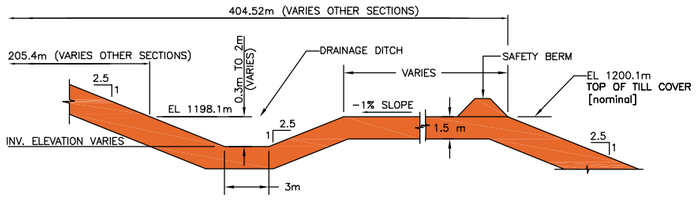
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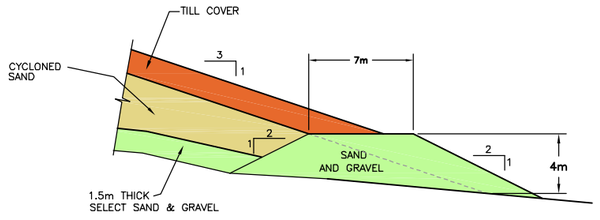
THIS SECTION TAKEN @ STN. 2+200

TYPICAL SECTION : STN. 2+100 TO STN. 2+450

SECTION D / FIG 4
SCALE: 1:2000



DETAIL 1
SCALE: 1:400



DETAIL 2
SCALE: 1:400

LEGEND

- BEACH TAILINGS
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 20%
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 10%
- COMPACTED GLACIAL TILL
- SAND AND GRAVEL

SCALE 0 100m

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PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L–L DAM CREST EL 1279m

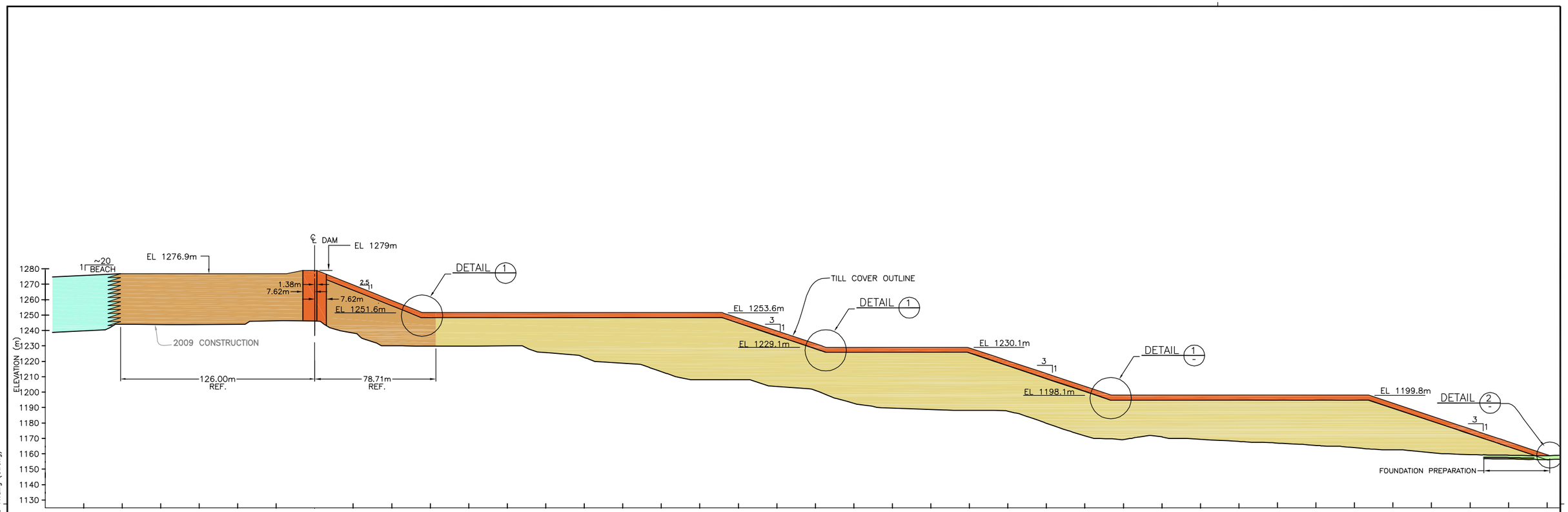
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STATION 2+200

PROJECT No. M02341A50

FIG. No. 12

KCB-4-MLD

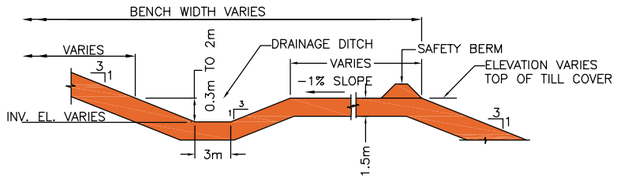
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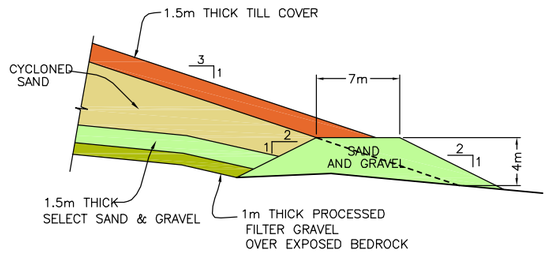
THIS SECTION TAKEN AT STN. 2+550

TYPICAL SECTION: STN. 2+450 TO STN. 2+750

SECTION E
SCALE 1:2500 FIG 4



DETAIL 1
SCALE 1:500



DETAIL 2
SCALE 1:500

LEGEND

- BEACH TAILINGS
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 20%
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 10%
- COMPACTED GLACIAL TILL
- SAND AND GRAVEL
- PROCESSED FILTER GRAVEL

SCALE 0 100m

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L-L DAM CREST EL 1279m

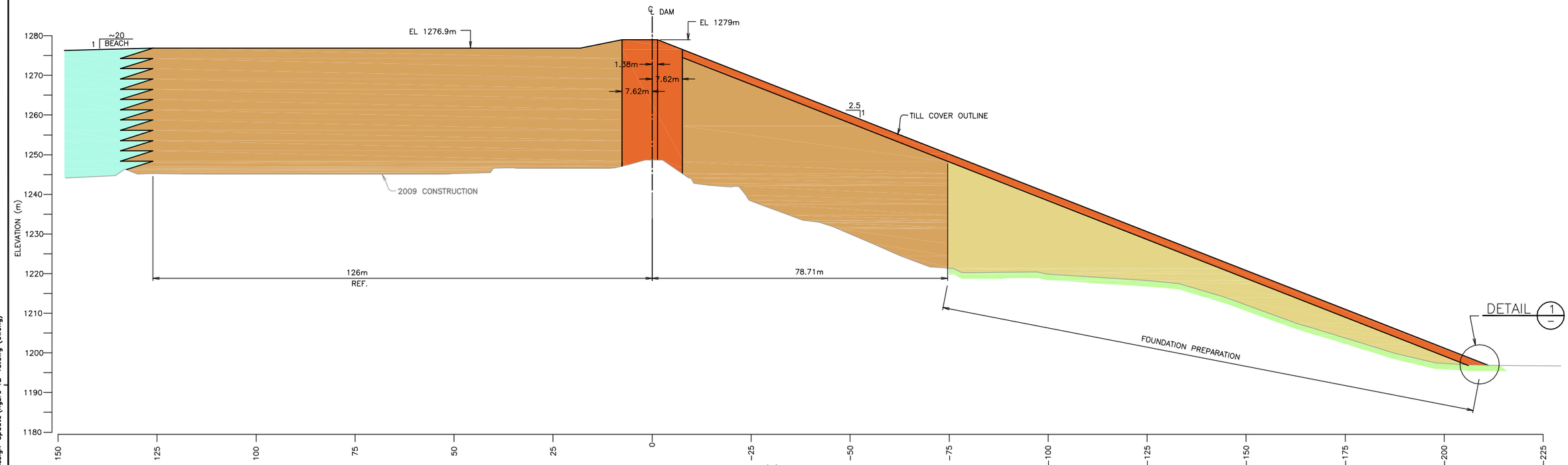
TITLE
L-L ULTIMATE DAM
STATION 2+550

PROJECT No. M02341A50

FIG. No. 13

KCB-R-MLD

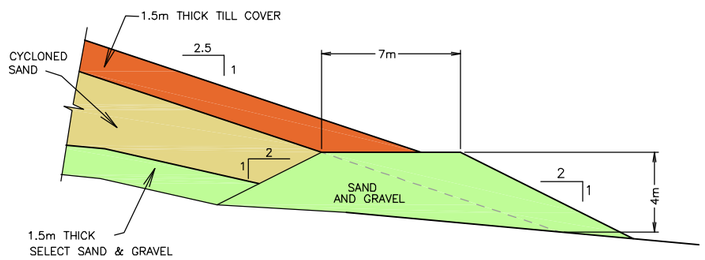
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Drawing File: M:\M02341A46 - HVC 2009 Tailings Facility\400 Design\410 Drawings\working-cy\2028-el1279\design-update\figure 11.dwg (cwong)



SECTION TAKEN AT STN. 2+900

TYPICAL SECTION : STN. 2+750 TO STN. 3+000

SECTION F
SCALE 1:1000 FIG 4



DETAIL 1
SCALE 1:300

LEGEND

- BEACH TAILINGS
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 20%
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 10%
- COMPACTED GLACIAL TILL
- SAND AND GRAVEL

SCALE 0 50m

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L-L DAM CREST EL 1279m

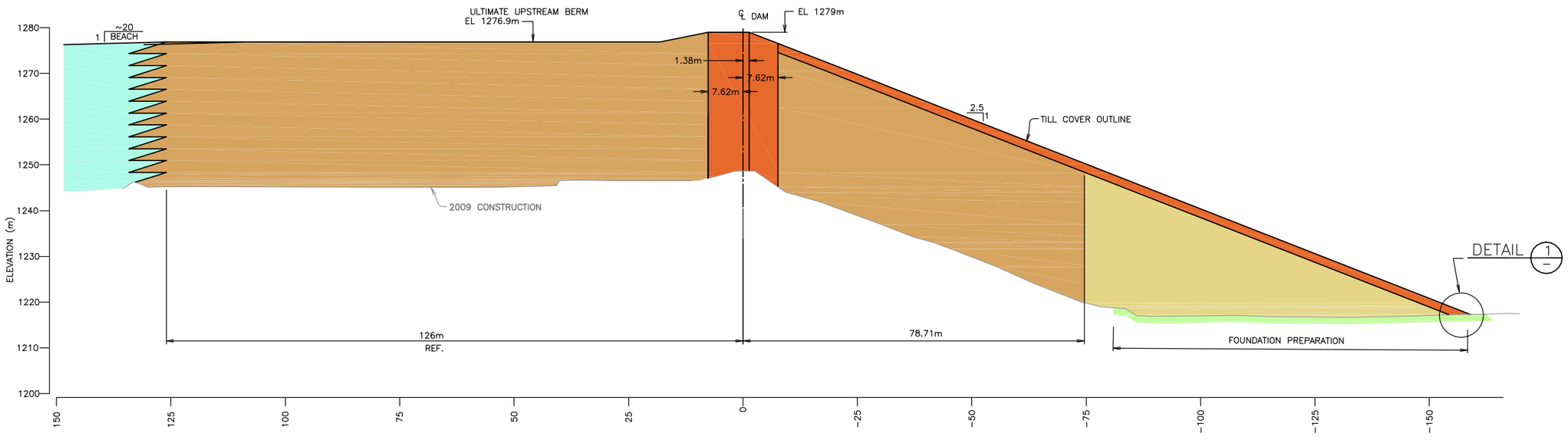
TITLE
L-L ULTIMATE DAM
STATION 2+900

PROJECT No. M02341A50

FIG. No. 14

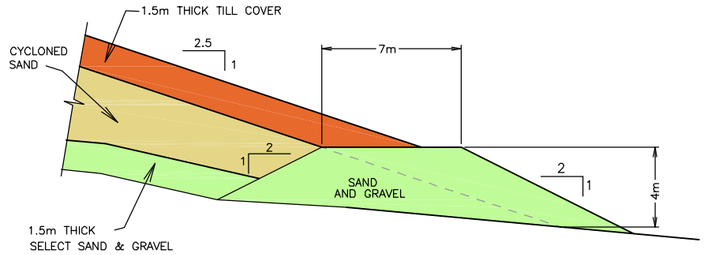
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Drawing File: M:\M02341A46 - HVC 2009 Tailings Facility\400 Design\410 Drawings\working-cy\2028-el1279\design-update\figure 12-13.dwg (cwong)



DISTANCE FROM CENTRELINE OF DAM (m)
SECTION TAKEN AT STN. 3+200
TYPICAL SECTION : STN. 3+000 TO STN. 3+670

SECTION G
SCALE 1:1000 FIG 4



DETAIL 1
SCALE 1:300

LEGEND

- BEACH TAILINGS
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 20%
- COMPACTED CYCLONED SANDFILL WITH FINES CONTENT < 10%
- COMPACTED GLACIAL TILL
- SAND AND GRAVEL

0 50m
SCALE

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L-L DAM CREST EL 1279m

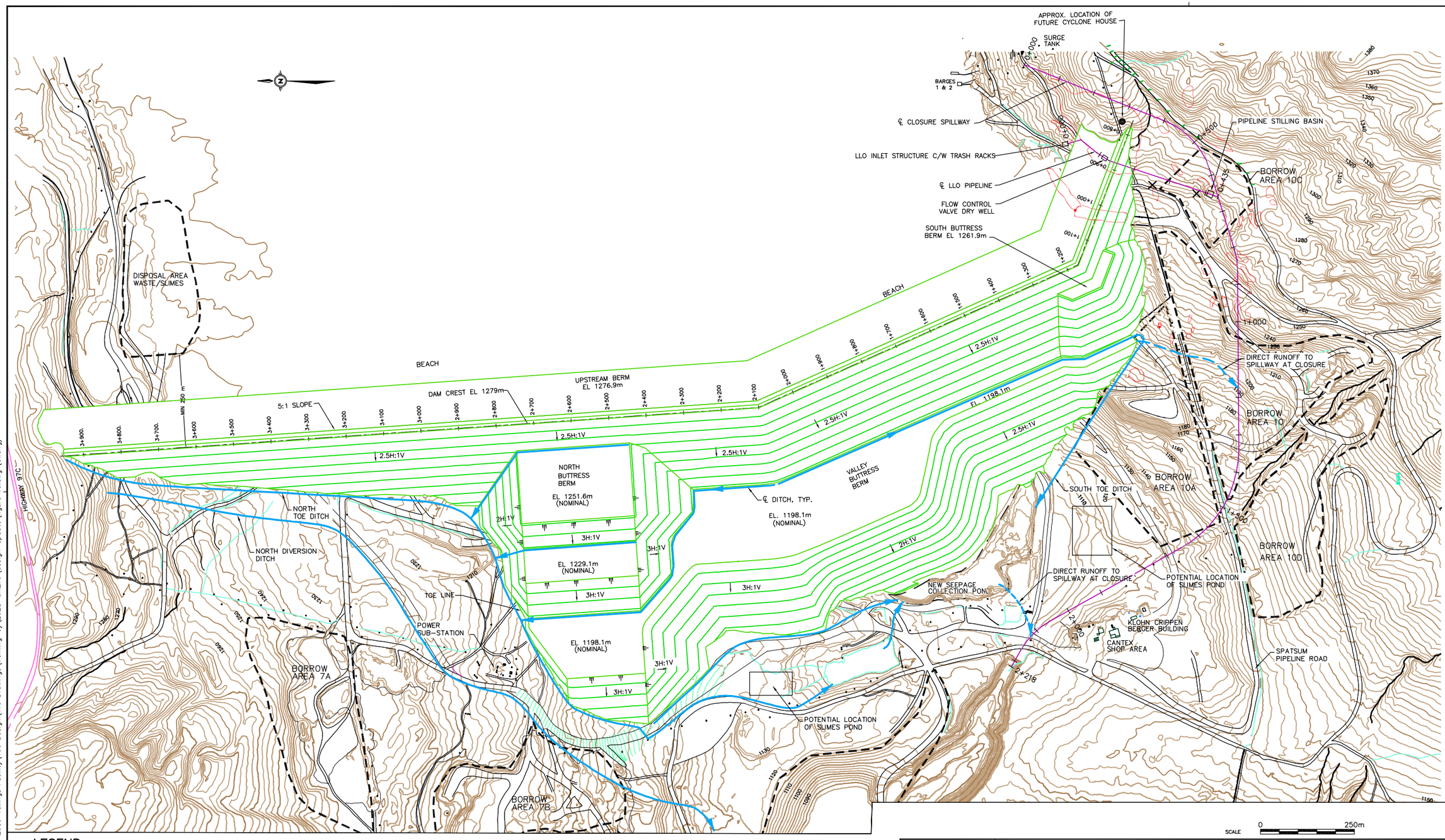
TITLE
L-L ULTIMATE DAM
STATION 3+200

PROJECT No. M02341A50

FIG. No. 15

K08-R-MLD

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Scale: 1=7(PS)
Drawing File: M:\M02341A46 - HVC 2009 Tailings Facility\400 Design\410 Drawings\working-cy\2028-el1279\design-update\figure 12-13.dwg (cwong)



LEGEND

- × ROCK OUTCROP LOCATION
- ROCK OUTCROP OUTLINE (NOTE 2)
- BORROW AREAS
- LLO LOW LEVEL OUTLET

NOTES:

1. TOPOGRAPHY PROVIDED BY TECK HIGHLAND VALLEY COPPER, JAN 27, 2010.
2. ROCK OUTCROP OUTLINES WERE MAPPED IN 1990.
3. DETAILS OF UPSTREAM DAM FILL TO SUIT LOW LEVEL OUTLET ARE TO BE DETERMINED.
4. FOR PROFILE OF SPILLWAY AND LOW LEVEL OUTLET SEE FIG. 18

SCALE 0 250m

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L-L DAM CREST EL 1279m

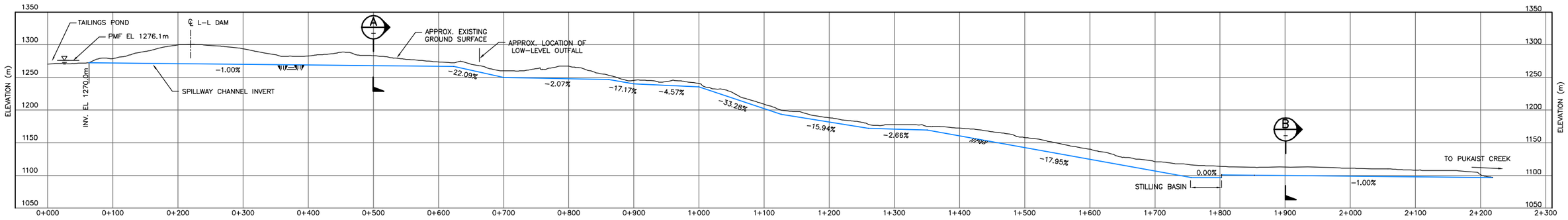
TITLE
ULTIMATE DAM
SPILLWAY, LLO AND DRAINAGE DITCHES
PRELIMINARY ARRANGEMENT-PLAN

PROJECT No. M02341A50

FIG. No. 17

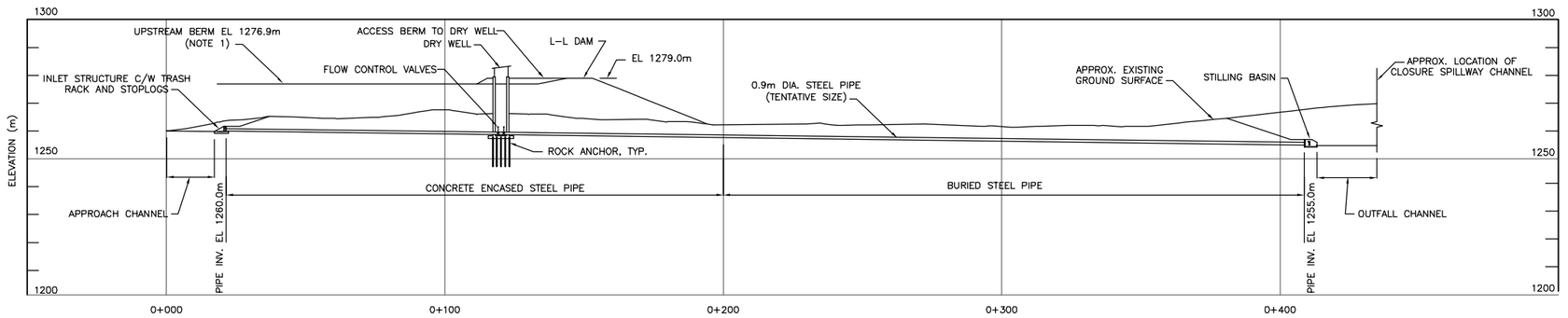
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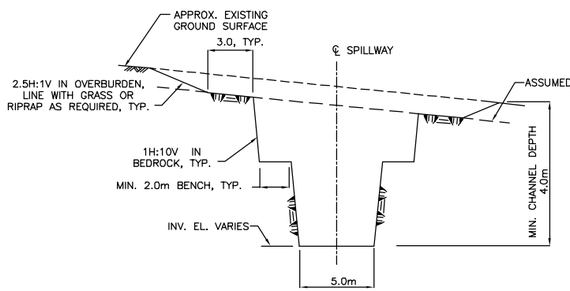
CLOSURE SPILLWAY PROFILE

(EXISTING AND PROPOSED ROADS NOT SHOWN)
SCALE A



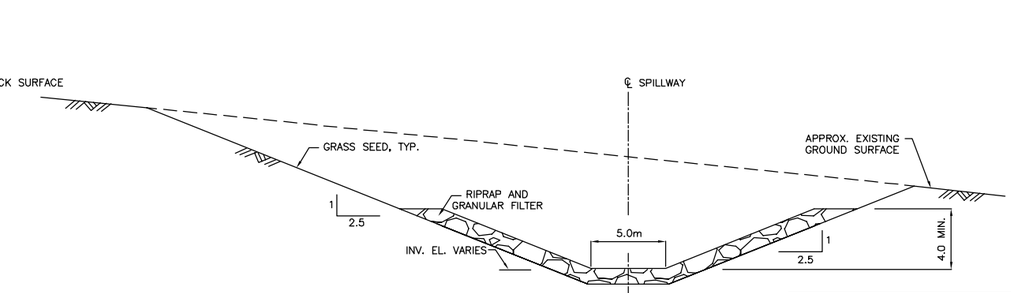
LOW LEVEL OUTLET PROFILE

SCALE B



SECTION A
SCALE C

TYP. SPILLWAY SECTION IN BEDROCK



SECTION B
SCALE C

TYP. SPILLWAY SECTION IN OVERBURDEN

NOTES:

1. DETAILS OF UPSTREAM BERM (EL 1276.9m) AND TAILING BEACH TO SUIT LOW-LEVEL OUTLET ARE TO BE DETERMINED.

SCALE

SCALE C 0 10m

SCALE B 0 50m

SCALE A 0 200m

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CLIENT

TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT

HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L-L DAM CREST EL 1279m

TITLE

ULTIMATE DAM
SPILLWAY AND LLO
PRELIMINARY PROFILES & TYP. SECTIONS

PROJECT No. M02341A50

FIG. No. 18

KCB-R-MLD

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Scale: 1:1
Drawing File: M:\M02341A46 - HVC 2009 Tailings Facility\400 Design\410 Drawings\working-cy\2028-el1279\design-update\figure 16.dwg (cwong)

APPENDIX III-B

H-H Dam

Appendix III-B
H-H Dam Overview

I-1 STRUCTURE OVERVIEW

The layout of the H-H Dam and associated structures is shown in Figure 4 of the main report. For context and reference, selected design drawings and typical cross sections attached to this appendix. As of the end of 2018, the crest elevation of H-H Dam ranged from El. 1273 m to 1280 m, corresponding to a maximum downstream slope height (crest to toe) of about 55 m. The dam height above original ground measured at the centerline is approximately 100 m but the waste dumps have elevated the existing ground downstream of the dam (~40 m) which reduces the slope height. References made throughout this document refer to those listed in main text.

The tailings beach slopes from the primary discharge points at the H-H Dam towards the pond near the L-L Dam which is ~9 km away. Therefore, no significant ponding occurs at the H-H Dam. The crest of the dam is sloped to match the forecast beach profile immediately upstream of the dam. The currently permitted ultimate crest of the H-H Dam is El. 1292.7 m to El. 1298 m, which corresponds to a maximum downstream slope height of approximately 65 m through the midpoint of the dam.

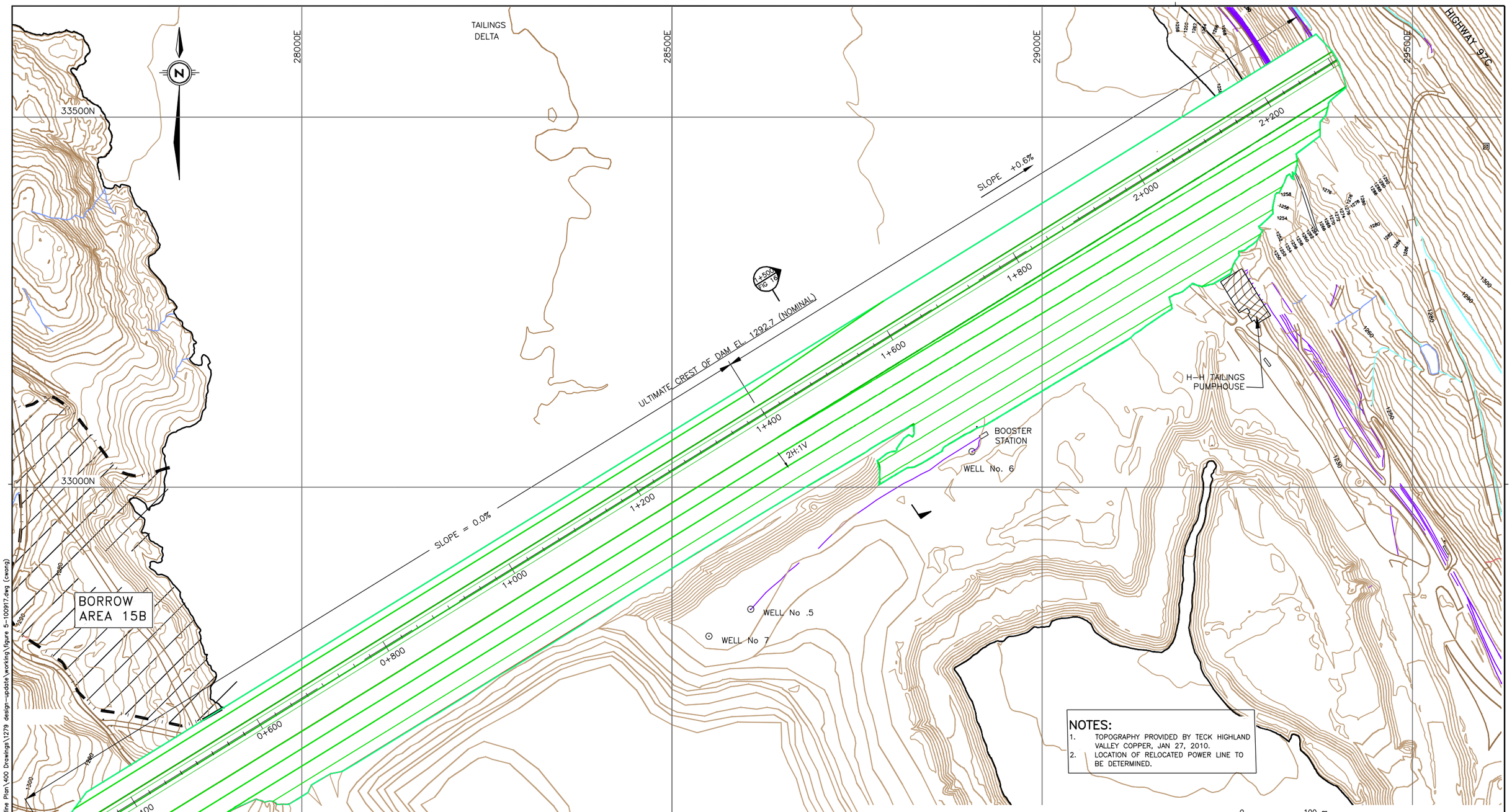
The layout of the H-H Dam is shown in Figure 4. Refer to the selected design drawings and typical cross sections, attached to this appendix, for reference. The dam was raised in late 2018 as documented 2018 construction summary report (in progress). General information regarding the dam is as follows:

- The starter dam construction records were reported by Bechtel (1972). Construction records of subsequent raises are contained in various construction summary reports (1978 to 2015).
- The foundation conditions at the H-H Dam are documented in the KCB report entitled “H-H Dam Performance Review Report” (KCB 2016), which should be referenced for details. The typical stratigraphic sequence beneath the H-H Dam, starting at surface, is as follows:
  - Upper Sand and Gravel;
  - Glacial Till;
  - Sand and gravel with interlayered silt and clay; and
  - Bedrock (Guichon Creek granodiorite).
- The dam comprises the following main elements (KCB 2010):
  - An earthfill starter dam, raised via the centerline method with a low permeability centreline vertical glacial till core, supported by random fill and tailings beach on the upstream side and variable mine waste fill on the downstream side.
  - Downstream slope of approximately 2H:1V, with a buttress of varying heights along the dam alignment, constructed of mine waste.
  - An approximately 6.8 m high lock-block retaining wall constructed at the east of the dam immediately adjacent to the H-H Pumphouse.
- Seepage from the H-H Dam reports to 24 Mile Lake.

I-2 HISTORICAL OVERVIEW

A brief history of the construction and operations at the H-H Dam is summarized below. This information was based on the construction summary reports prepared from 1978 to 2015. In general, up to 1993, the H-H Dam was constructed by Contractors using local borrow materials. From 1993 onwards, the portion of dam downstream of the core and downstream filter zone (SG2 fill zone) is constructed by THVCP, employing its own equipment and workforce, using select waste material from the Valley Pit. This was carried out in 2016 with intermittent placement of downstream RF2 fill out to the ultimate dam profile (between Sta. 0+540 and Sta. 1+600, up to approximately El. 1271 m).

- The starter dam was constructed in 1972 to El. 1193.6 m (Bechtel 1972). Following completion of the starter dam, the dam has been raised on a regular basis (typically annually).
- After about 1992, the downstream shell was raised by end-dumping sand and gravel (random fill) material in up to 10 m thick lifts with only traffic compaction by construction equipment (i.e., haul trucks). A 10 m wide “transition zone” immediately downstream of the glacial till core was typically compacted in thinner (2 m) lifts (KCB 2016).
- From about 2003 to 2007, a waste dump was constructed downstream of the dam which raised the original ground at the toe from El. 1195 m to about El. 1224 m to El. 1227 m (KCB 2016). The waste dump was constructed in about 10 m thick lifts with the top of each lift compacted by construction equipment traffic.
- Between about 2008 and 2009, the downstream side of the dam was further raised to about El. 1255.5 m across most of the dam length using Bethsaida sand (sand and gravel fill) with similar construction procedures as per the random fill:
  - Over approximately the same period, a portion of the waste dump along the western end of H-H Dam (i.e. from about Sta. 0+600 to Sta. 1+200) was raised as high as El. 1290 m.
  - Along the eastern end of H-H Dam (i.e. from about Sta. 1+500 to Sta. 1+950), and immediately upstream of 24 Mile Lake, the waste dump was maintained at about El. 1224 m.
- In 2010, a filter zone was added between the glacial till core and the downstream fill zones (KCB 2010).
- A 6.8 m high lock block retaining wall was designed by Sadé Engineering Associates (SEA) and constructed by THVCP during 2012 at the toe of the dam at Sta. 2+020.
- In 2014, a rockfill buffer zone was added along the upstream edge of the dam to mitigate erosion by tailings slurry (KCB 2014b).
- There was no construction at the H-H Dam in 2015. Construction resumed in 2016 and two dam raises were completed in 2018. KCB (2019) summarizes construction activity and includes record drawings.



NOTES:
1. TOPOGRAPHY PROVIDED BY TECK HIGHLAND VALLEY COPPER, JAN 27, 2010.
2. LOCATION OF RELOCATED POWER LINE TO BE DETERMINED.

SOURCE: BASED ON KLOHN CRIPPEN BERGER DWG. B-16003.

SCALE 0 100 m

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L-L DAM CREST EL 1279m

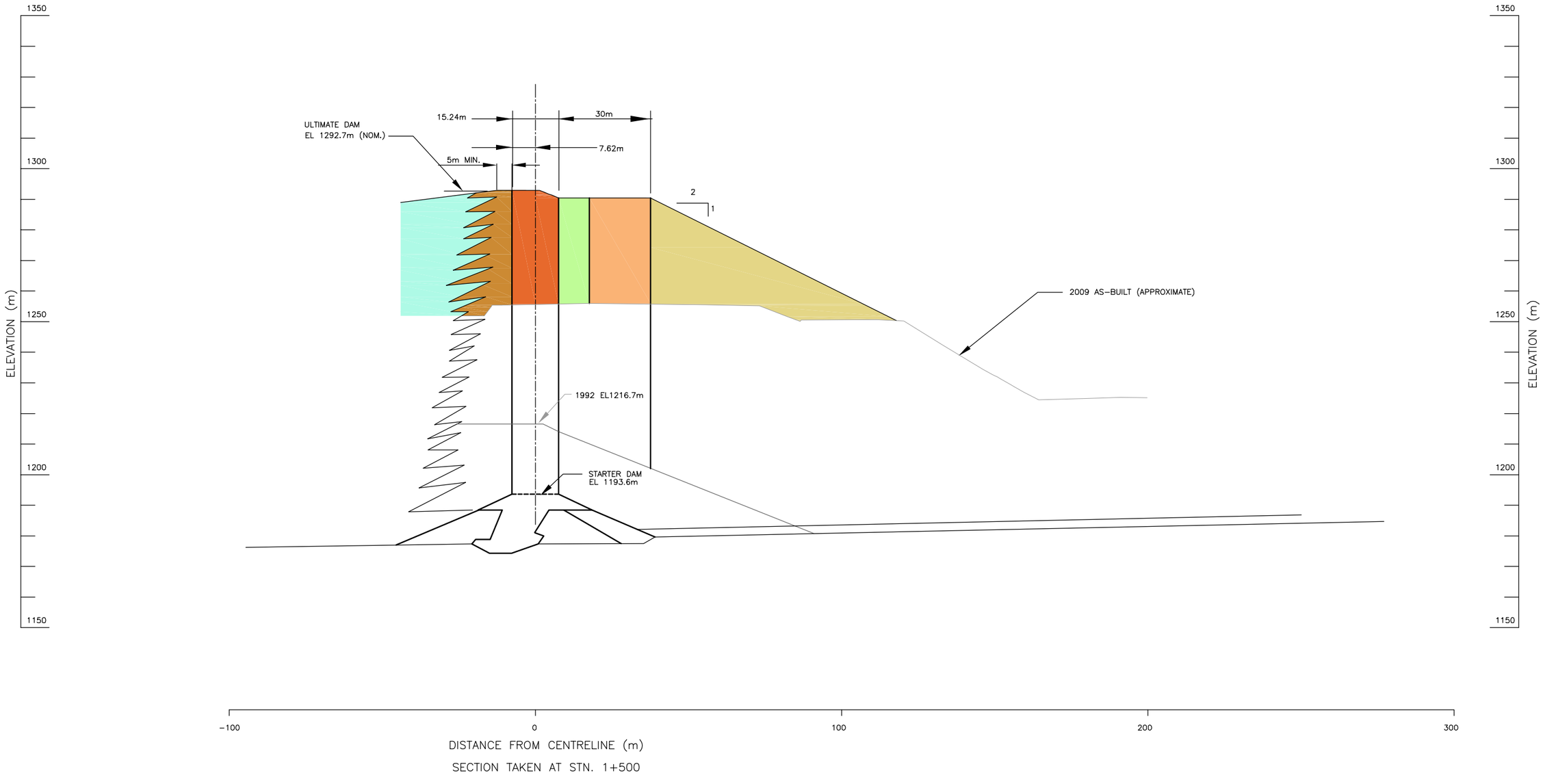
TITLE
H-H DAM GENERAL ARRANGEMENT
ULTIMATE DAM

PROJECT No. M02341A50

FIG. No. 5

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Date: 9/23/2010
User: kwong
Drawing File: N:\M02341A50 - HVC 2028 Mine Plan\400 Drawings\1279 design-update\working\figure 5-100917.dwg (xwong)



SECTION TAKEN AT STN. 1+500

LEGEND

- BEACH TAILINGS
- UPSTREAM RANDOM FILL
- DOWNSTREAM TRANSITION STRUCTURAL FILL
- DOWNSTREAM RANDOM ROCKFILL OR EARTH FILL
- COMPACTED GLACIAL TILL
- SAND AND GRAVEL

TO BE READ WITH KLOHN CRIPPEN REPORT DATED _____

SCALE 0 50m

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CLIENT

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Klohn Crippen Berger

PROJECT

HIGHLAND TAILINGS STORAGE FACILITY
DESIGN UPDATE FOR L-L DAM CREST EL 1279m

TITLE

H-H ULTIMATE DAM STATION 1+500

PROJECT No. M02341A50

FIG. No. 16

KCB-TM

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Date: 9/16/2010
Scale: 1=4(PS)
Drawing File: M:\M02341A50 - HVC 2028 Mine Plan\400 Drawings\1279 design-update\working\figure 8-100916.dwg (cwong)

APPENDIX III-C

L-L Dam Seepage and Slimes Ponds

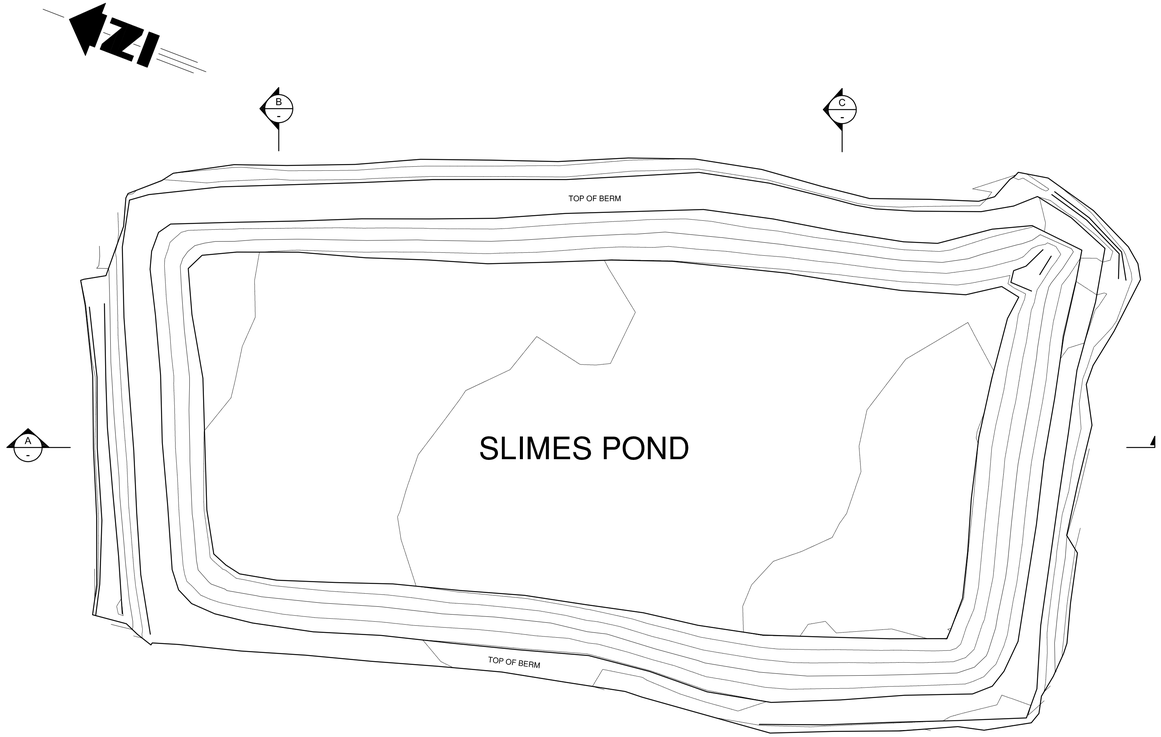
APPENDIX III-C-1

Seepage Pond 1

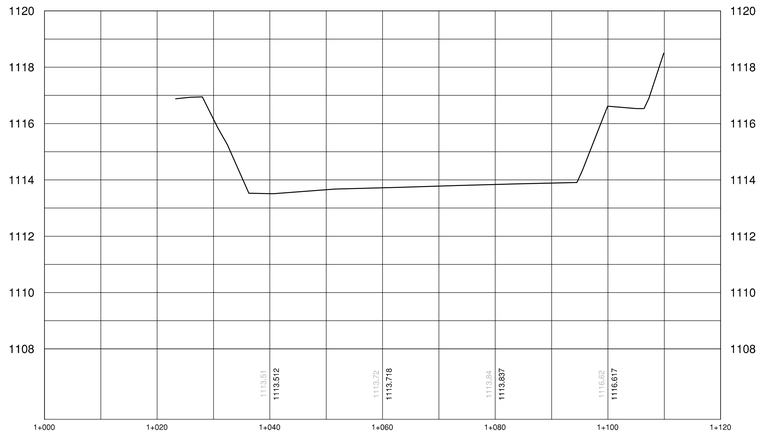
Drawings Not Available

APPENDIX III-C-2

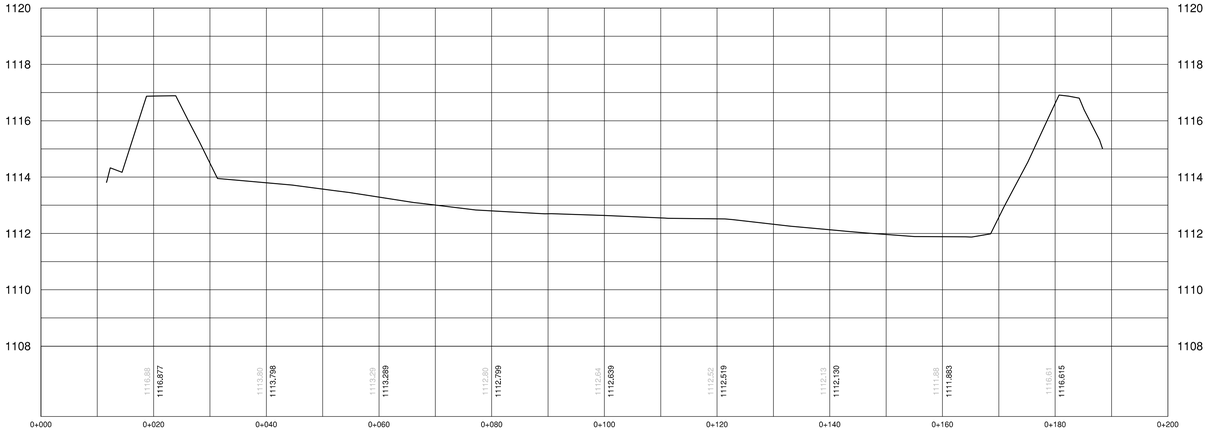
Seepage Pond 2



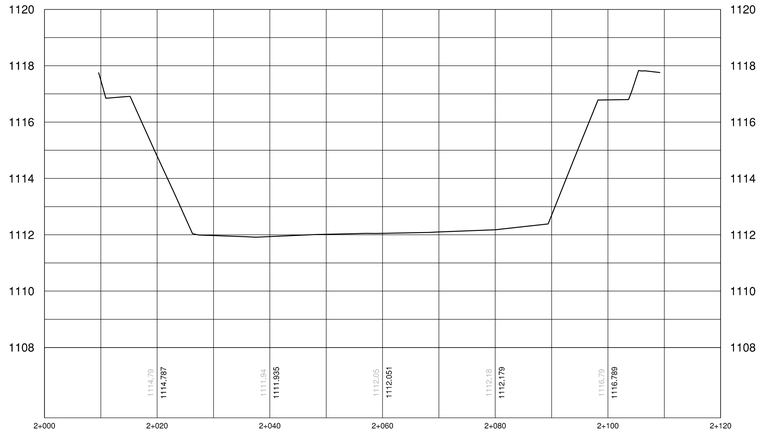
PLAN VIEW
SCALE - 1:500



B SECTION
H - 1:500
V - 1:100



A SECTION
H - 1:500
V - 1:100



C SECTION
H - 1:500
V - 1:100

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TRUE CONSULTING
201 - 2079 Falcon Road
Kamloops BC V2C 4J2
tel 250.828.0881
fax 250.828.0717
info@TRUE.bc.ca

DESIGNED: .	CHECKED: .
DRAWN: .	DATE: .
SCALE .	CAD FILE: .

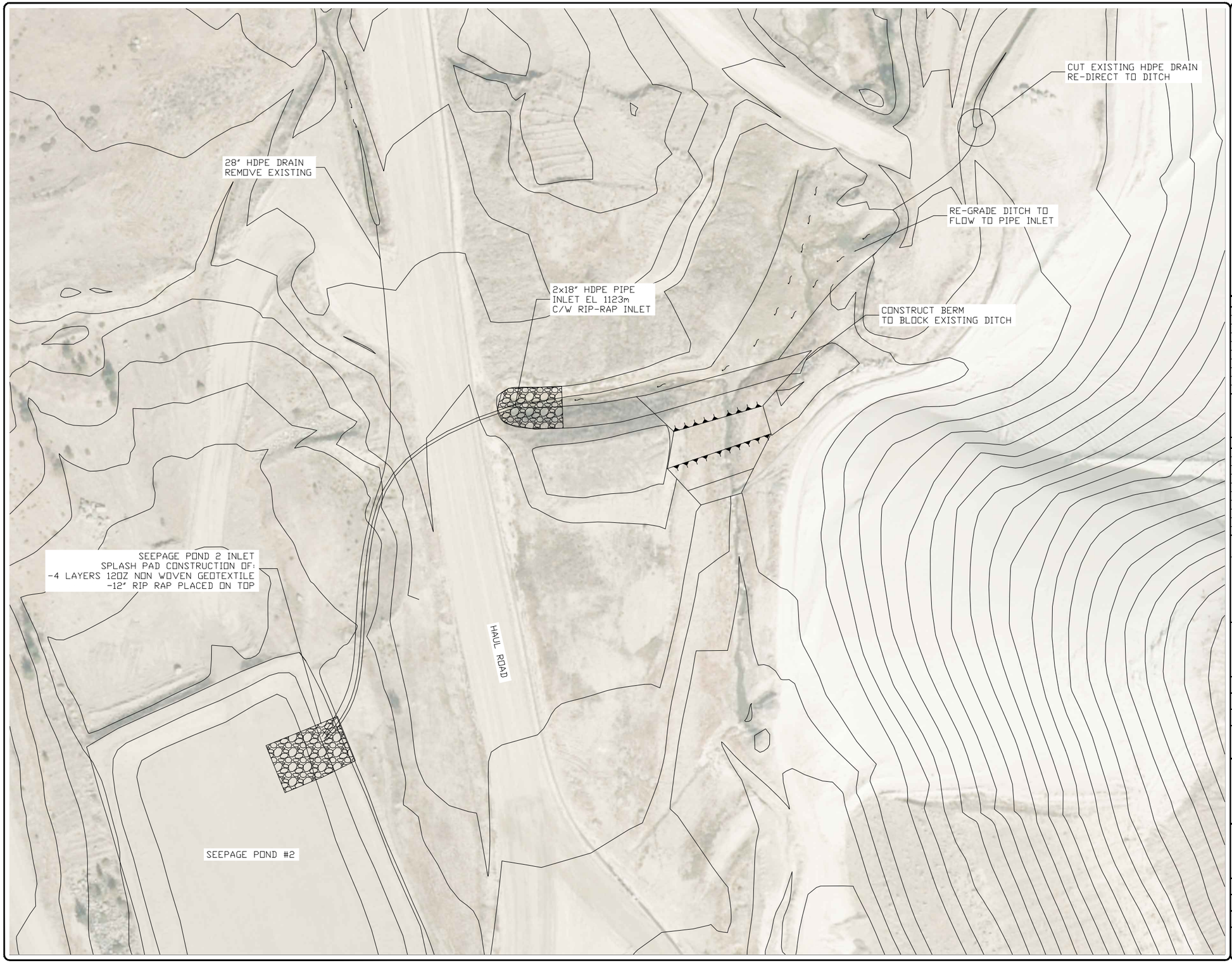
DWG NO: .
REV. .

SLIMES POND PLAN AND SECTIONS

Highland Valley Copper
Teck

HVC DESIGN: .	HVC CHECKED: .
HVC DRAWN: SC	DATE: SEPTEMBER 2012
SCALE 1:500	HVC CAD FILE: 1011-021-SlimePond-ASB.dwg

HVC DWG NO: —
REV. .



NO.	ISSUE	DATE	BY	CHKD	APPD

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REF.	DWG. NO.	REFERENCE DRAWING DESCRIPTION

ISSUED FOR:

DESIGNED:	CHECKED:
DRAWN:	DATE:
SCALE	CAD FILE:

DWG NO: REV. △

SEEPAGE POND #2
DITCH DESIGN

Highland Valley Copper
Teck

HVC DESIGN:	HVC CHECKED:
HVC DRAWN: B STEANE	DATE: FEBRUARY 2013
SCALE As Shown	HVC CAD FILE:

HVC DWG NO: REV. △

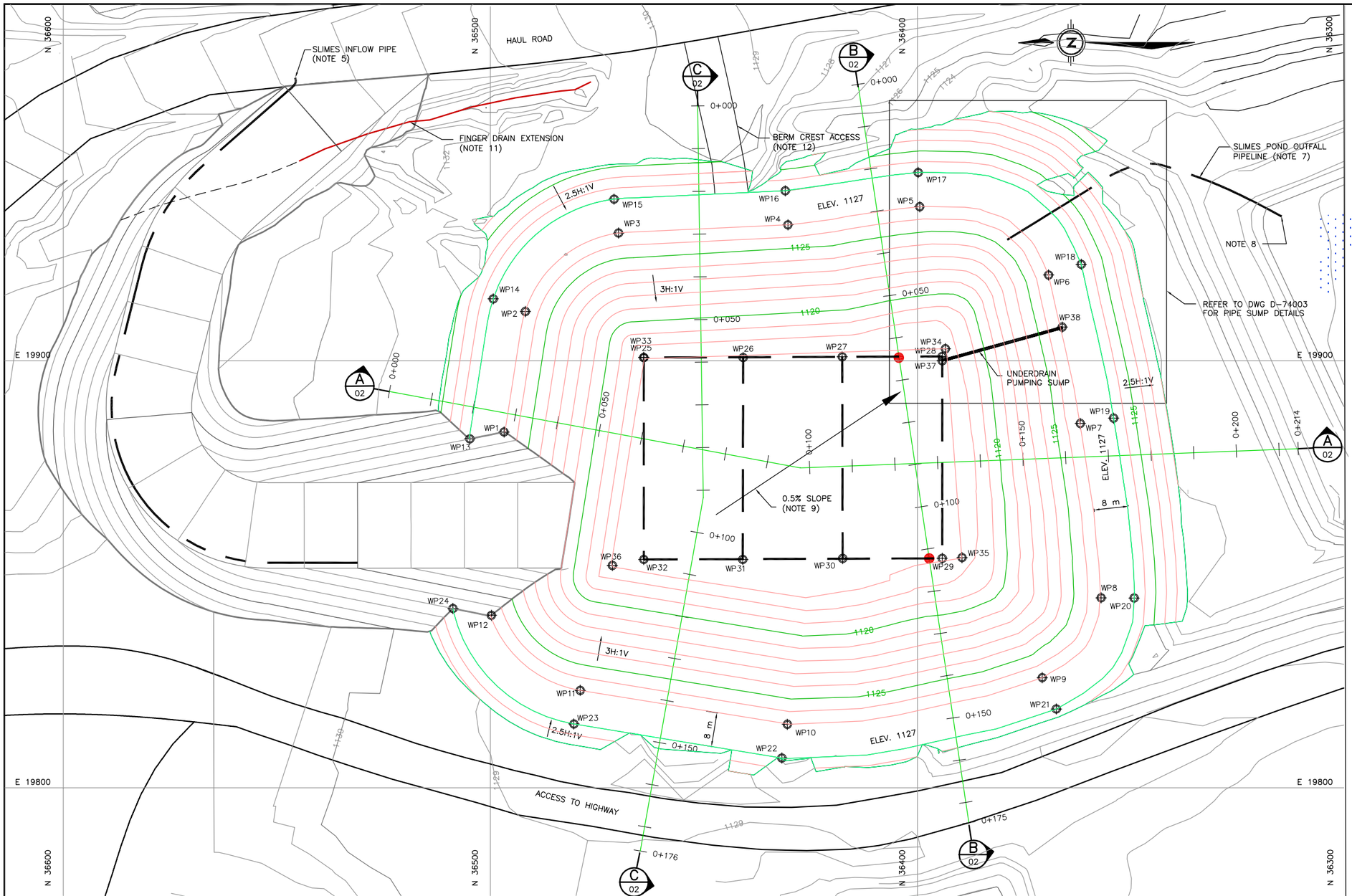
APPENDIX III-C-3

Slimes Pond 1

Drawings Not Available

APPENDIX III-C-4

Slimes Pond 2



WORK POINT	EASTING (m)	NORTHING (m)	ELEVATION (m)	LOCATION
WP1	19883.3	36496.8	1127.0	8m BERM CREST
WP2	19911.5	36491.8	1127.0	
WP3	19929.9	36470.0	1127.0	
WP4	19931.8	36430.3	1127.0	
WP5	19936.1	36399.5	1127.0	
WP6	19920.1	36369.3	1127.0	
WP7	19885.3	36361.9	1127.0	
WP8	19844.5	36357.0	1127.0	
WP9	19825.8	36370.8	1127.0	
WP10	19814.9	36430.5	1127.0	
WP11	19822.8	36479.0	1127.0	
WP12	19840.4	36499.8	1127.0	
WP13	19881.7	36504.8	1127.0	
WP14	19914.5	36499.3	1127.0	
WP15	19937.8	36471.0	1127.0	
WP16	19939.8	36431.0	1127.0	
WP17	19944.1	36399.8	1127.0	
WP18	19922.6	36361.7	1127.0	
WP19	19886.5	36354.1	1127.0	
WP20	19844.4	36349.3	1127.0	
WP21	19818.4	36367.5	1127.0	
WP22	19807.0	36431.8	1127.0	
WP23	19814.9	36480.5	1127.0	
WP24	19842.0	36508.8	1127.0	
WP25	19900.7	36464.1	—	UNDERDRAIN PIPE (NOTE 9)
WP26	19900.7	36440.8	—	
WP27	19900.7	36417.6	—	
WP28	19901.0	36394.2	—	
WP29	19853.5	36394.2	—	
WP30	19853.5	36417.5	—	
WP31	19853.5	36440.9	—	
WP32	19853.5	36464.1	—	
WP33	19900.7	36464.1	1117.0	EXCAVATION BASE
WP34	19902.8	36393.5	1117.0	
WP35	19853.9	36389.6	1117.0	
WP36	19852.1	36471.4	1117.0	
WP37	19900.0	36394.2	1117.1	UNDERDRAIN PUMPING SUMP
WP38	19907.9	36366.1	1127.0	

BILL OF QUANTITIES (NOTE 3)

EXCAVATION	46745 m^3
FILL	8356 m^3
AVAILABLE SLIMES STORAGE	53120 m^3
GEOMEMBRANE SURFACE AREA INCLUDING ANCHOR TRENCH	20080 m^2

LEGEND

UNDERDRAIN (NOTE 4)

VIBRATING WIRE PIEZOMETER (NOTE 10)

NOTES

1. BASE MAP FROM HVC 2013 CONTRACT DRAWING AND SLIMES POND EXISTING CONDITION SURVEY RECEIVED FROM HVC AUGUST 15, 2014.
2. ALL DIMENSIONS ARE IN METRES UNLESS NOTED.
3. VOLUMES ARE NEAT-LINE COMPACTED OR IN SITU WITH NO BULKING FACTOR OR CONTINGENCY. GEOMEMBRANE AREA INCLUDES 10% CONTINGENCY FOR OVERLAP AND WASTAGE.
4. UNDERDRAIN PIPE DETAILS PROVIDED ON DWG. D-74002.
5. SLIMES INFLOW PIPE DETAILS TO BE DETERMINED BY HVC BUT NOT TO EXCEED SINGLE 24" DIA PIPE PLACED ALONG FIELD FIT ACCESS/MAINTENANCE RAMP.
6. SLIMES INFLOW PIPE DISCHARGE TO BE SET BELOW ELEV. 1125.5 m. LOCALLY PLACE RIPRAP (D_{50} = 0.3 m) IMMEDIATELY DOWNSTREAM OF THE DISCHARGE LOCATION (2 m WIDTH, 4 m LENGTH).
7. SLIMES POND OUTFALL PIPELINE, MINIMUM GRADE OF 2% REQUIRED ALONG ENTIRE ALIGNMENT. HVC SPECIFIED 36-INCH DR26 HDPE PIPE.
8. DETAILS OF DISCHARGE INTO SEEPAGE POND 2 TO BE DIRECTED BY QC ENGINEER IN THE FIELD.
9. UNDERDRAINS TO BE GRADED AT 0.5% (OVERALL) SLOPE TOWARDS SOUTHEAST CORNER, FIELD FIT DURING INSTALLATION.
10. REFER TO D-74002 FOR PIEZOMETER DETAILS. LOCATIONS TO BE SELECTED BY QC ENGINEER IN THE FIELD.
11. FIELD FIT EXTENSION TO FINGER DRAIN BELOW ACCESS RAMP AS DIRECTED BY QC ENGINEER, USING PROCESSED FILTER GRAVEL SURROUNDED BY AT LEAST 0.3 m THICKNESS OF SELECT SAND AND GRAVEL.
12. FIELD FIT BERM CREST ACCESS RAMP TO MAINTAIN MINIMUM 0.9 m COVER DEPTH OVER EXISTING BURIED PIPE.
13. ACCESS/MAINTENANCE RAMP WILL BE FIELD FIT BY HVC AND QC ENGINEER WITH MAXIMUM SLOPE 8%. LAYOUT ON THIS DRAWING SHOWN AS REFERENCE EXAMPLE.

REVISION	DESCRIPTION OF REVISION	DATE (YYYY-MM-DD)	DRAWN	DESIGNED	CHECKED	APPROVED
1	RAMP RE-ALIGNED	2014-10-14	CYW	RF	AM	NS
0	ISSUED FOR CONSTRUCTION	2014-08-28	CYW	RF	AM	NS

ISSUED FOR CONSTRUCTION

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY

TITLE
SLIMES POND 2 EARTHWORKS PLAN

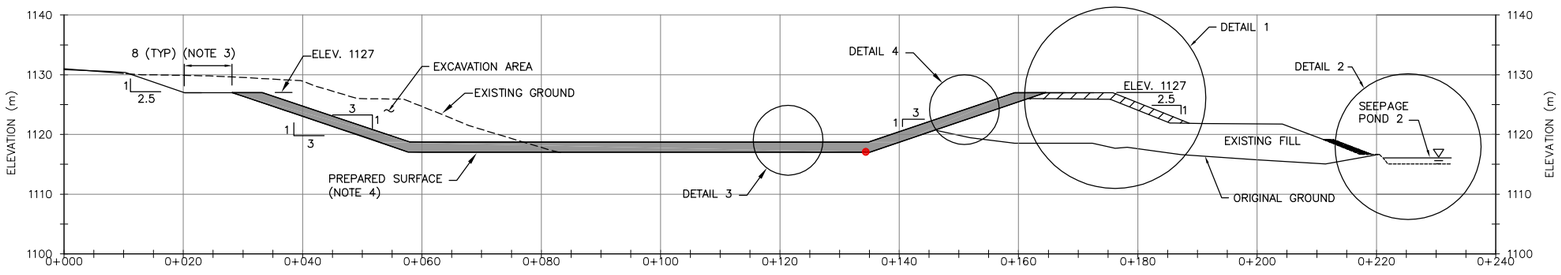
SCALE	PROJECT NO.	DWG. NO.	REV.
AS SHOWN	M02341A74	D-74001	1

CANCEL PRINTS BEARING PREVIOUS REVISION

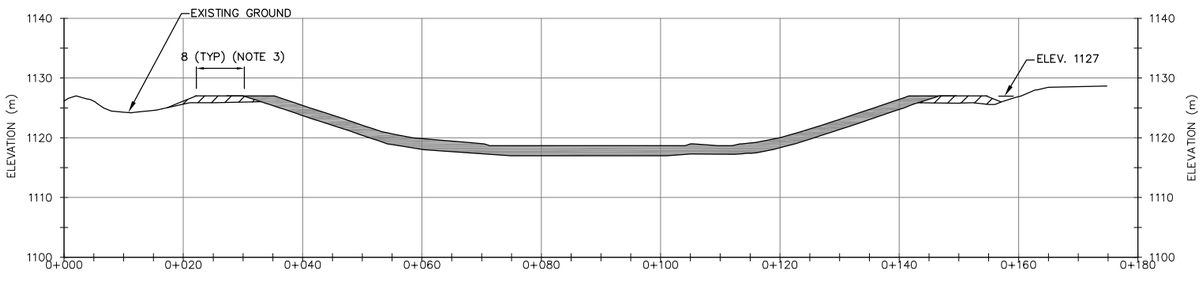
KCB-DWG-D-L

0 25 m

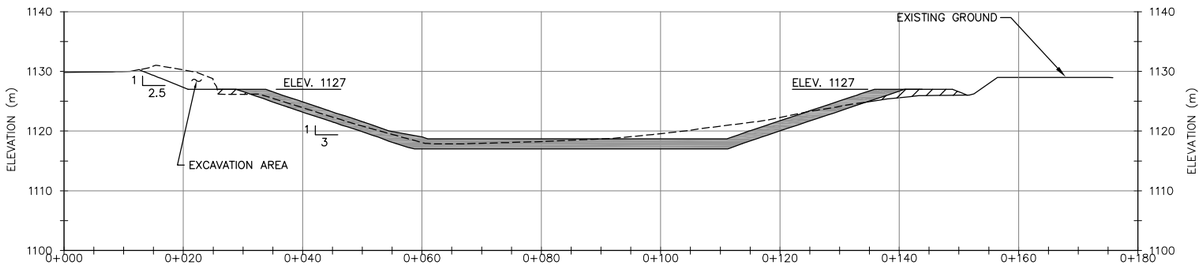
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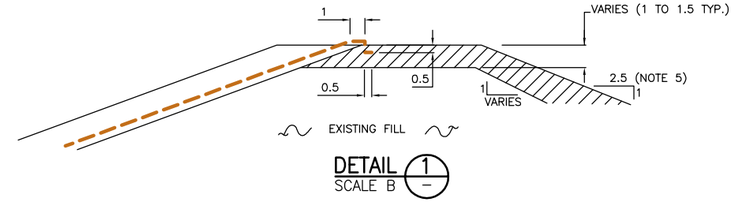
SECTION A (01)
SCALE A



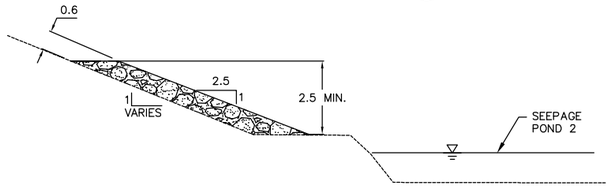
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SCALE A



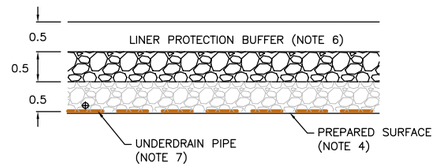
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SCALE A



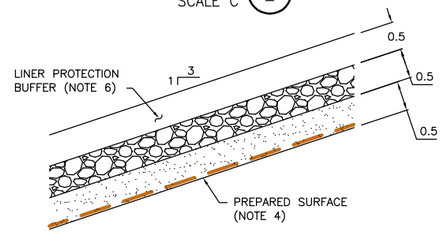
DETAIL 1
SCALE B



DETAIL 2
SCALE C



DETAIL 3
SCALE D



DETAIL 4
SCALE D

NOTES

1. BASE MAP FROM HVC 2013 CONTRACT DRAWING AND SLIMES POND EXISTING CONDITION SURVEY RECEIVED FROM HVC AUGUST 15, 2014.
2. ALL DIMENSIONS ARE IN METRES UNLESS NOTED.
3. FILL CREST AND EXCAVATION BENCH WIDTHS HAVE BEEN SET FOR SINGLE LANE TRAFFIC (LIGHT VEHICLE AND 30 TONNE HAUL TRUCKS) WITH AN ALLOWANCE FOR SAFETY BERMS TO BE SIZED AND PLACED BY HVC.
4. GRADE AND COMPACT THE TILL SURFACE TO THE DESIGN LINES. RE-GRADE EXISTING SLOPES AS REQUIRED TO ACHIEVE MAXIMUM 3H:1V SLOPE FOR GEOMEMBRANE. FLATTEN SMALL RIDGELINES LEFT BY THE PACKER AND INFILL LOCAL DEPRESSIONS. REMOVE PEBBLES LARGER THAN 1 INCH NOMINAL SIZE OR, IF FEASIBLE, FORCE THEM INTO THE UNDERLYING TILL WITH THE VIBRATORY COMPACTOR. COVER ANY LOCAL GRAVEL/COBBLE ZONE (IF PRESENT) WITH FINE GRAINED TILL AND COMPACT. ALTERNATIVELY, 12.5 mm MINUS SAND AND GRAVEL MAY BE PLACED LOCALLY AS REQUIRED AND COMPACTED TO ACHIEVE A SMOOTH SURFACE.
5. FILL SLOPE TO EXTEND DOWN TO EXISTING GROUND OR FILL LEVEL.
6. FOR CALCULATION OF AVAILABLE SLIMES STORAGE, A 0.5 m BUFFER OF UNREMOVED SLIMES WAS ASSUMED ABOVE GEOMEMBRANE PROTECTION FILL.
7. UNDERDRAIN LAYOUT AS ON DWG. D-74001, 150 mmø ARMTEC BOSS-2000 DUAL WALL CORRUGATED HDPE PERFORATED DRAINAGE PIPE WITH FILTER SOCK. 4-90° ELBOWS AND 4-TEE JUNCTIONS.

PIPE DIAMETER	SLOT WIDTH	SLOT LENGTH	SLOT TYPE
150 mm	1.5 mm	17 mm	PATTERN #1

8. SOLMAX 480T-2000 HDPE TEXTURED GEOMEMBRANE (HVC SPECIFIED)
9. FILL GRADATION AND PLACEMENT SPECIFICATIONS SHOWN ON DWG. D-74004.
10. RST VW2100-HD HEAVY DUTY VIBRATING WIRE PIEZOMETER, 0.35 MPa PRESSURE RANGE, 60 m CABLE LENGTH. SATURATE TIP WITH WATER BEFORE INSTALLATION. DIG A HOLE IN THE PREPARED SURFACE, INSTALL PIEZOMETER WITH TIP POINTING UP, AND BACKFILL WITH 20-40 FILTER SAND. INSTRUMENT CABLE TO RUN INSIDE A 2-INCH Ø DR11 HDPE PIPE, RUNNING UP THE SLOPE IN A TRENCH BACKFILLED WITH TILL, AND ACROSS THE CREST BELOW THE LEVEL OF THE LINER ANCHOR TRENCH TO A READOUT LOCATION ON THE DOWNSTREAM SLOPE. INSTRUMENTS ARE TO BE READ BI-WEEKLY AS GEOMEMBRANE LEAK DETECTION.

LEGEND

- GLACIAL TILL (NOTE 9)
- UNDERFLOW SAND (NOTE 9)
- SAND AND GRAVEL FILTER (NOTE 9)
- PROCESSED BLAST ROCK (NOTE 9)
- SAND AND GRAVEL DRAINAGE LAYER (NOTE 9)
- LINER SYSTEM
- GEOMEMBRANE (NOTE 8)
- VIBRATING WIRE PIEZOMETER (NOTE 10)
- UNDERDRAIN PIPE (NOTE 7)

SCALE A 0 25 m
SCALE B 0 10 m
SCALE C 0 5 m
SCALE D 0 2.5 m

ISSUED FOR CONSTRUCTION

REVISION	DESCRIPTION OF REVISION	DATE (YYYY-MM-DD)	DRAWN	DESIGNED	CHECKED	APPROVED
1	REVISED UNDERDRAIN SPECIFICATIONS	2014-10-14	CYW	FS	AM	NS
0	ISSUED FOR CONSTRUCTION	2014-08-28	CYW	RF	AM	NS

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY

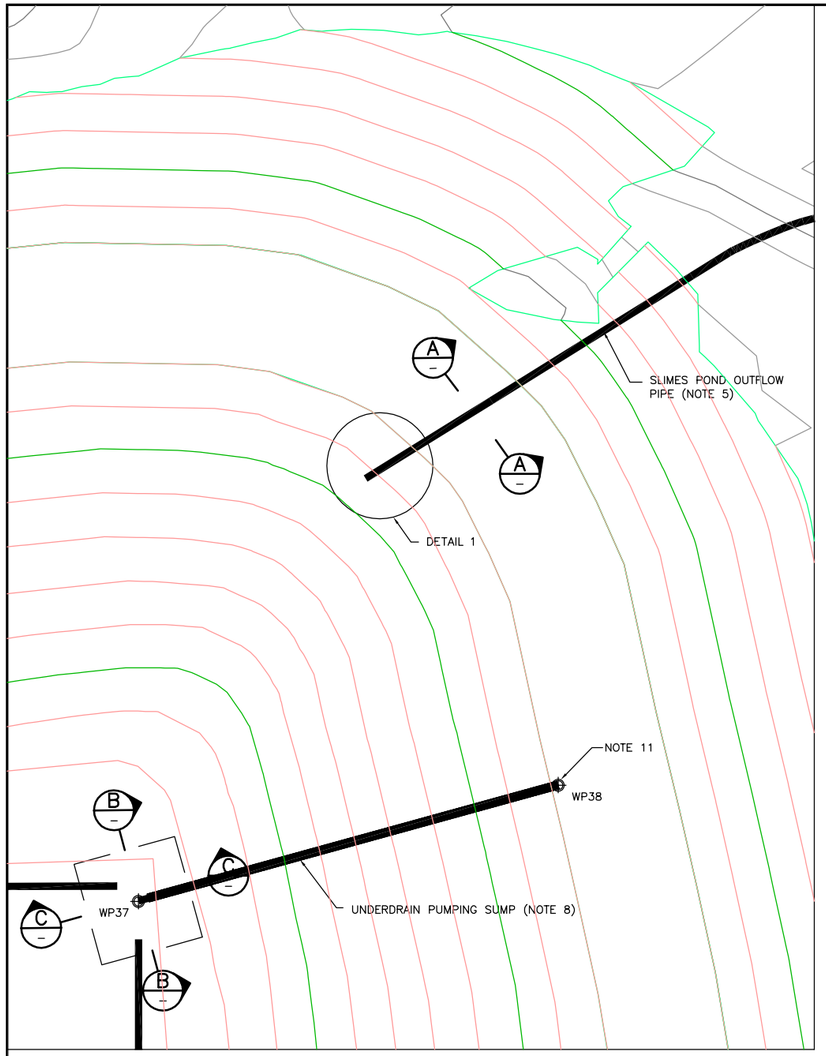
TITLE
SLIMES POND 2
CROSS SECTIONS AND
LINER DETAILS

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AS SHOWN	M02341A74	D-74002	1

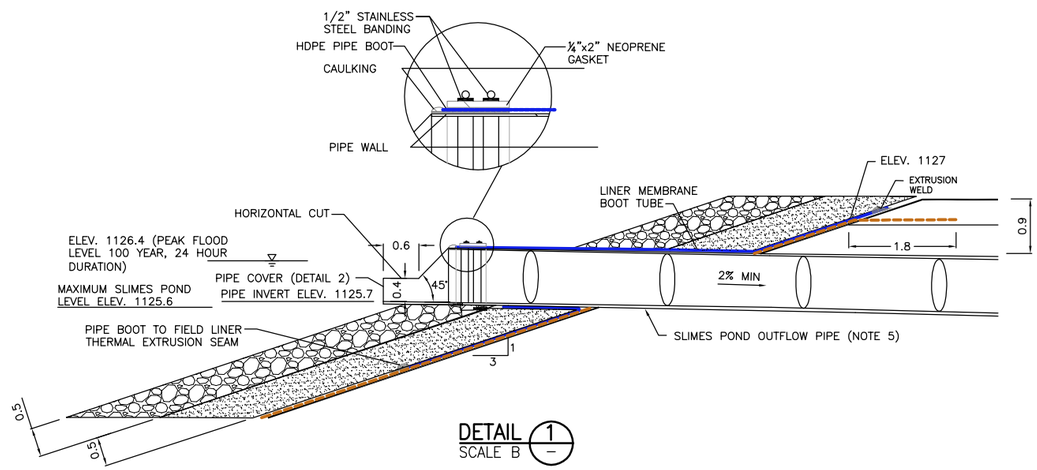
CANCEL PRINTS BEARING PREVIOUS REVISION

KCB-DWG-D-L

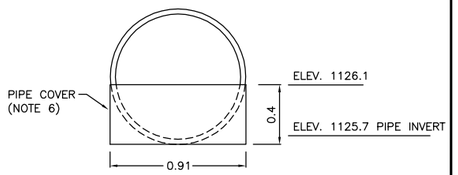
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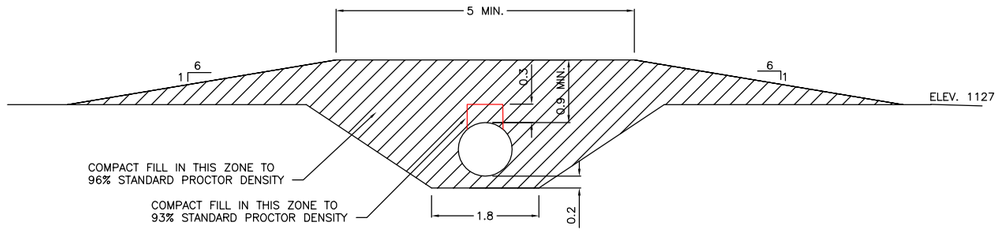
PIPE DETAIL
SCALE A



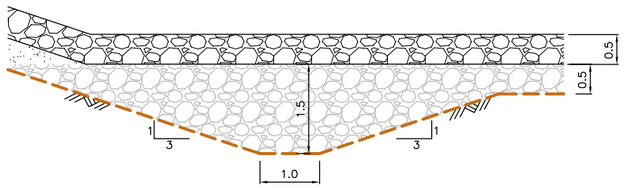
DETAIL 1
SCALE B



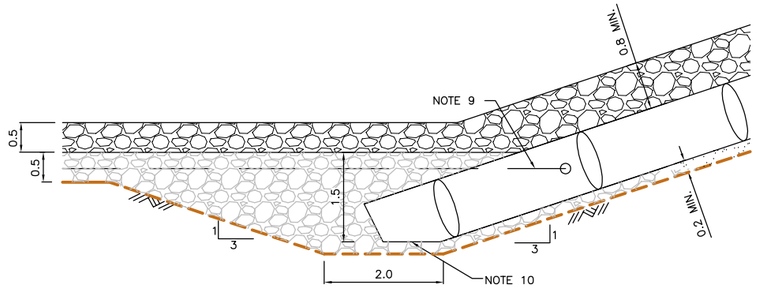
DETAIL 2
SCALE C



SECTION A
SCALE B
TYPICAL PIPE BURIAL DETAIL



SECTION B
SCALE B
SUMP



SECTION C
SCALE B
SUMP

LEGEND

- GLACIAL TILL (NOTE 3)
- UNDERFLOW SAND (NOTE 3)
- SAND AND GRAVEL DRAINAGE LAYER (NOTE 3)
- PROCESSED BLAST ROCK
- GEOMEMBRANE (NOTE 4)
- GEOMEMBRANE PIPE BOOT (NOTE 7)
- PIPELINE IN SECTION

NOTES

1. BASE MAP FROM HVC 2013 CONTRACT DRAWING AND SLIMES POND EXISTING CONDITION SURVEY RECEIVED FROM HVC AUGUST 15, 2014.
2. ALL DIMENSIONS ARE IN METRES UNLESS NOTED.
3. FILL GRADATION AND PLACEMENT SPECIFICATIONS SHOWN ON DWG D-74004
4. SOLMAX 480T-2000 HDPE TEXTURED GEOMEMBRANE (HVC SPECIFIED)
5. HVC SPECIFIED 36-INCH DR26 HDPE PIPE.
6. PIPE COVER TO BE STEEL, HDPE OR EQUIVALENT MATERIAL, APPROVED BY QC ENGINEER, TO BE SECURED TO PIPE OPENING USING STAINLESS STEEL BOLTS WITH SEALANT PLACED AROUND CONTACT POINTS AND BOLTS BETWEEN PIPE COVER AND OUTFLOW PIPE. ARRANGEMENT CAN BE FIELD FIT WITH QC ENGINEER APPROVAL.
7. GEOMEMBRANE PIPE BOOT TO BE INSTALLED ACCORDING TO MANUFACTURER'S SPECIFICATIONS.
8. 36-INCH DR26 HDPE PIPE.
9. UNDERDRAIN PIPES TO DISCHARGE INTO UNDERDRAIN PUMPING SUMP. IF CONNECTIONS CANNOT BE WELDED, CUT HOLES IN SIDES OF SUMP PIPE, INSERT UNDERDRAIN PIPES AND STUFF AND SECURE GEOTEXTILE IN GAPS.
10. END OF PIPE TO BE CUT SO IT IS PLACED HORIZONTAL AND CAPPED WITH WELDED HDPE.
11. REMOVABLE TOP CAP TO PREVENT ANIMAL ACCESS AND FOR FROST PROTECTION.

REVISION	DESCRIPTION OF REVISION	DATE (YYYY-MM-DD)	DRAWN	DESIGNED	CHECKED	APPROVED
1	ADDED SUMP DETAILS	2014-10-14	CYW	RF	AM	NS
0	ISSUED FOR CONSTRUCTION	2014-10-14	CYW	RF	AM	NS

SCALE A 0 10 m
SCALE B 0 2.5 m
SCALE C 0 1 m

NOT FOR CONSTRUCTION
DRAFT

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PROVINCE OF BRITISH COLUMBIA
OCT/16/2014

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY

TITLE
SLIMES POND 2
OUTFLOW PIPE AND UNDERDRAIN
SUMP DETAILS

SCALE	PROJECT NO.	DWG. NO.	REV.
AS SHOWN	M02341A74	D-74003	1

CANCEL PRINTS BEARING PREVIOUS REVISION

KCB-DWG-D-L

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Xref File(s):
Image File(s):

Material	Source	Gradation	Placement Method/Specification
Glacial Till	Pond Excavation	> 30% passing No. 200 Sieve	Minimum 96% Standard Proctor. Above outflow pipe: refer to DWG D–74003.
Underflow Sand	Cyclones on Dam Crest	Maximum of 10% passing the No. 200 sieve	Liner Bedding: Single lift, 2 passes with 10t vibratory smooth drum roller. Above Liner: 0.5 m lift, 4 overlapping passes with 10t smooth drum roller (no vibration).
Sand and Gravel Drainage Layer	From Stockpile	Clean 25 mm minus with less than 5% passing the No. 200 sieve	0.5 m lift, 4 overlapping passes with 10t smooth drum roller (no vibration).
Sand and Gravel Filter	Borrow Area 3	Clean 150 mm minus with less than 5% passing the No. 200 sieve	Placed with excavator bucket and tamped in place with bucket (heavy tamping as directed by QC Engineer).
Processed Blast Rock	Blast Rock	300 mm minus	0.5 m lift, 6 overlapping passes with D8 (or equivalent sized dozer) or 10t vibratory smooth drum roller.
Riprap	Blast Rock	See Table 2	Placed with excavator in an interlocking pattern as directed by QC Engineer.

	MINIMUM	MAXIMUM
D_{100}	450	510
D_{85}	360	420
D_{50}	300	345
D_{15}	120	180

ISSUED FOR CONSTRUCTION

REVISION	DESCRIPTION	DATE (YYYY–MM–DD)	DRAWN	DESIGNED	CHECKED	APPROVED
1	REVISED DESCRIPTION	2014–10–14	CYW	RF	AM	NS
0	ISSUED FOR CONSTRUCTION	2014–08–28	CYW	RF	AM	NS

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PROJECT
HIGHLAND TAILINGS STORAGE FACILITY

TITLE
SLIMES POND 2
FILL AND PLACEMENT
SPECIFICATIONS

SCALE	PROJECT NO.	DWG. NO.	REV.
AS SHOWN	M02341A74	D–74004	1

CANCEL PRINTS BEARING PREVIOUS REVISION

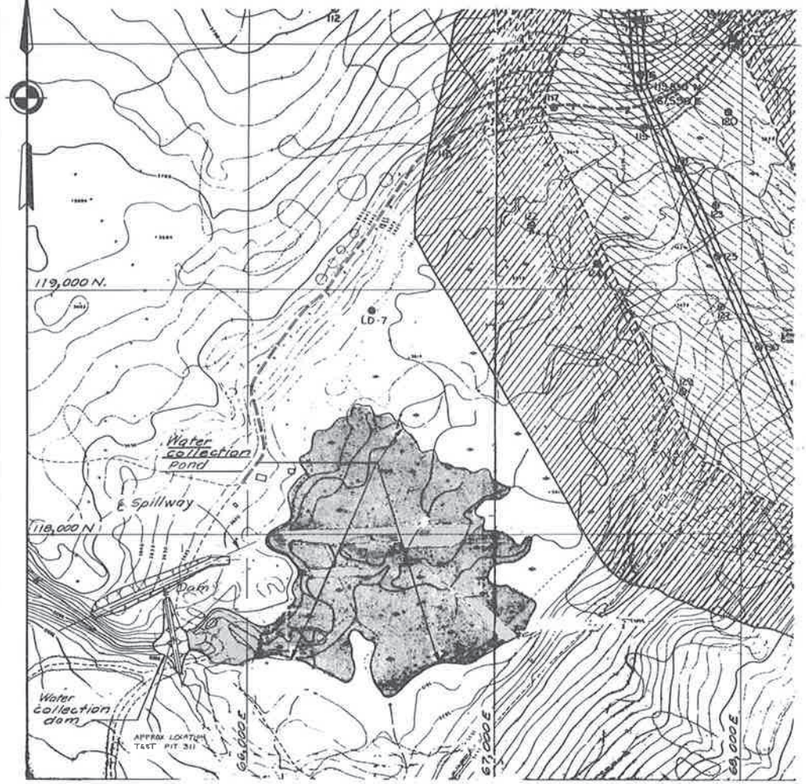
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APPENDIX III-C-5

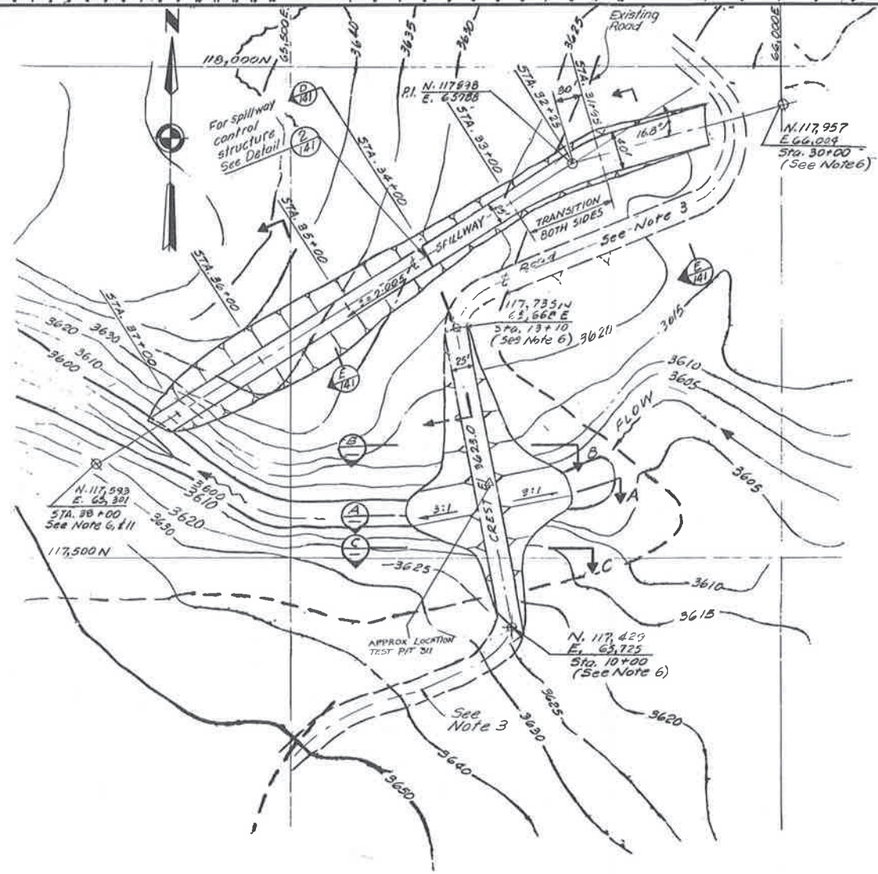
Seepage Water Reclaim Pond

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LOCATION OF WATER COLLECTION POND

Scale : 1" = 200'



PLAN

Scale : 1" = 50'

NOTES:

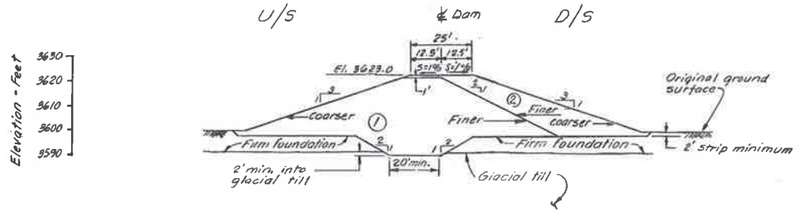
1. Original ground lines idealized for simplication.
2. Topography furnished by Lornex Mining Corporation Ltd. (Dwg. No. III-803-150 Dated May 19, 1976).
3. Connection of existing road to Dam to be determined in the field based upon actual ground contours.
4. Suitable borrow material for Zone 1 shall be obtained from spillway excavation as approved by the Manager. After using all suitable Zone 1 material from spillway excavation Zone 1 shall be obtained from borrow areas shown on Dwg. III-803-106.
5. Borrow material for Zone 2 shall be obtained from Borrow Area 3 as indicated on Dwg. III-803-106.
6. These coordinates and stations are approximate and are to be verified in field by the Manager.
7. Stations of channel entrance and outlet to be determined in field based upon actual ground contours.
8. Limits of clearing and grubbing are areas to be covered by the dam and spillway plus a strip 10 Ft. wide measured horizontally around them in all directions. Clearing shall consist of felling and removing all standing trees, brush, down trees, logs and debris. Grubbing shall include removal of all stumps, roots larger than 1-½" diameter and matted roots.
9. Waste material shall be disposed of in any borrow area shown on drawing III-803-106 or as approved by the Manager.
10. If there is a surplus of suitable Zone 1 material from the spillway excavation this material should be used as Zone 1 material in the L-L Dam as approved by the Manager.
11. Spillway excavation line and end are based upon Lornex survey January, 1977.

LEGEND

(1) Glacial till
(2) Sand and Gravel

REFERENCE DRAWINGS:

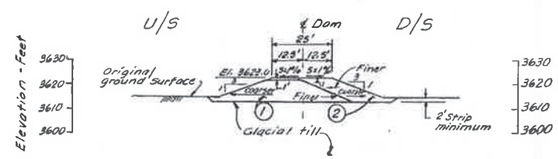
III-803-106 Investigation Borrow Plan
III-803-141 Excavation Profile, and Spillway Details.



SECTION A

TYPICAL SECTION ALONG CREEK BED

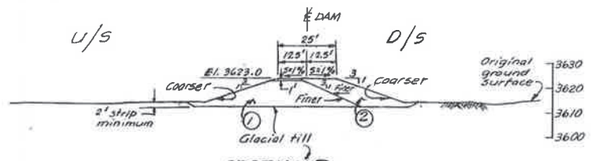
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SECTION C

TYPICAL LEFT ABUTMENT SECTION

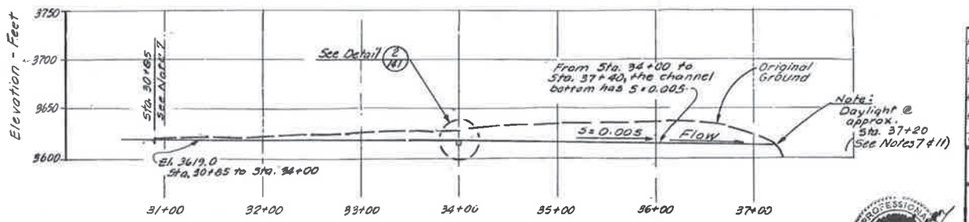
Scale : 1" = 20'



SECTION B

TYPICAL RIGHT ABUTMENT SECTION

Scale 1" = 20'



SPILLWAY CHANNEL PROFILE

Scale : 1" = 50'

Graphic Scale in Feet

0 10 20 40 60
1" = 20'

0 50 100 150
1" = 50'

0 100 200 400 600
1" = 200'

NO	DATE	REVISIONS	BY	CHK'D	PROJ. SUPT.	PROJ. ENGR.	APPD.
3	3-8-77	Issued for construction	YN	GS		SD	RB
2	1-7-77	ISSUED FOR REVIEW	YN	SD		SS	RB

SCALE AS SHOWN | DESIGNED S. SPICER | DRAWN P.C. | CHK'D ALY | PROJ. ENGR.

CANADIAN BECHTEL LTD
TORONTO, ONT.

RIO ALGOM MINES LTD.
LORNEX HIGHLAND VALLEY PROJECT

WATER COLLECTION DAM L-L AXIS

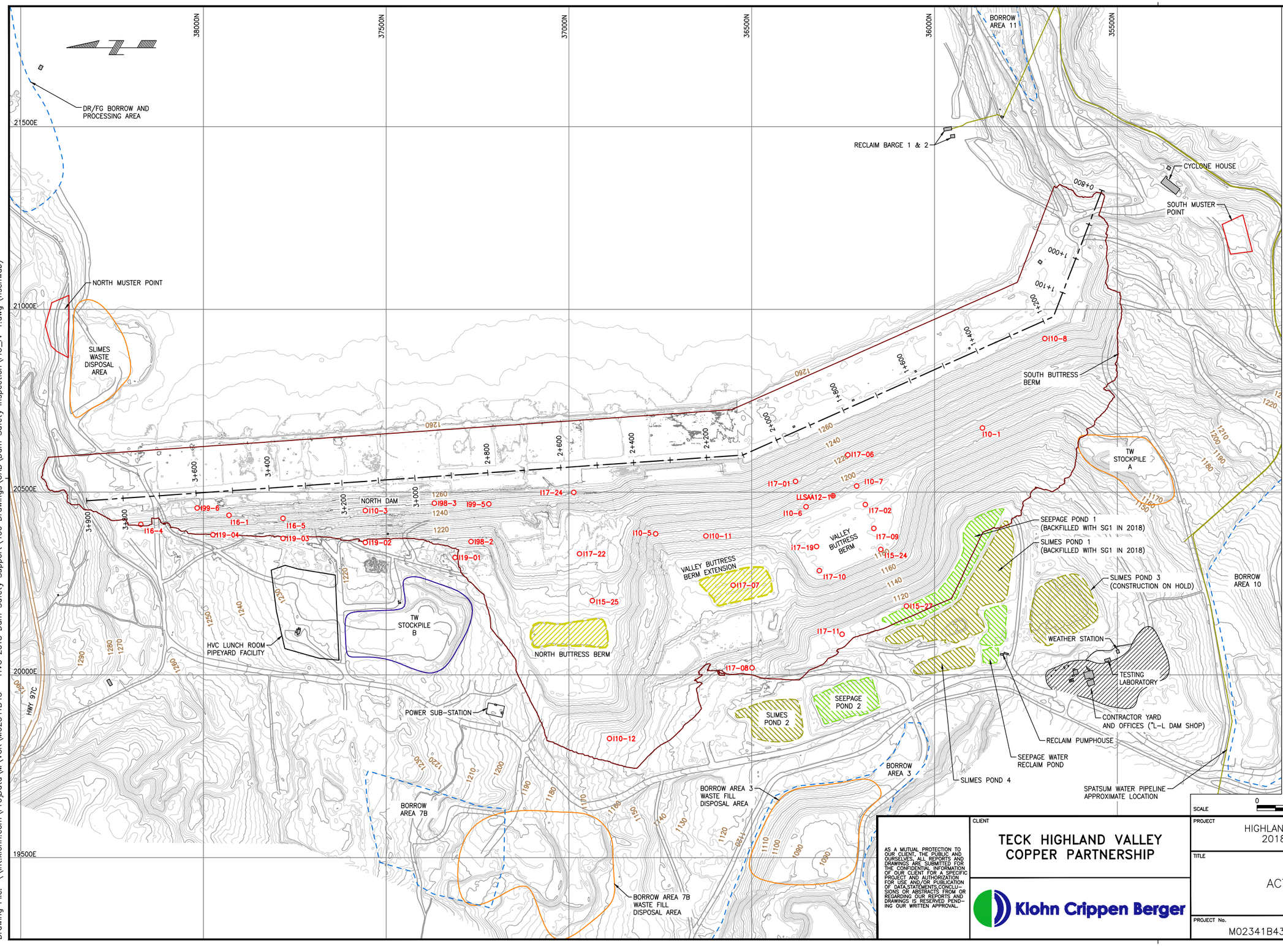
PLAN AND SECTIONS

BECHTEL CANADA | JOB No. 9039 | DRAWING No. III-803-140 | REV. 1

APPENDIX IV

Inclinometer Plots

INCLINOMETER LOCATION PLAN



LEGEND:

- BORROW AREA
- WASTE FILL DISPOSAL AREA
- SEEPAGE POND
- SLIMES POND
- EL. 1279 m ULTIMATE DAM FOOTPRINT
- SURFACE WATER RECLAIM PIPELINE
- SPATSUM WATER PIPELINE
- HAUL ROAD
- PUBLIC ROAD
- L-L DAM CENTERLINE (0+800)

ACTIVE INSTRUMENTS (SEE NOTE 2):

- STANDARD INCLINOMETER
- IN-PLACE SAA INCLINOMETER

NOTES:

1. TOPOGRAPHY OF L-L DAM IS GENERALLY BASED ON THE FOLLOWING:
   - AREAS OUTSIDE THE DAM FOOTPRINT ARE BASED ON OCTOBER 2018 PHOTOSAT SURVEY.
   - AREAS OF HYDRAULICALLY PLACED FILLS ARE BASED ON AS-BUILT SURVEYS PROVIDED BY TECK HIGHLAND VALLEY COPPER DATED 2018-12-10 (II-HS-3), 2018-11-14 (I-HS-1), 2018-10-22 (I-HS-2), 2018-12-05 (VBBE) AND 2018-12-17 (I-HS-4).
   - AREAS OF MECHANICALLY PLACED FILLS (SG1, S1 AND S2) AND FOUNDATION EXCAVATIONS (I-E-1, I-E-2, I-A-1, I-A-2, II-E-1, II-E-2, II-E-3) ARE GENERALLY BASED ON AS-BUILT SURVEYS PROVIDED BY NORTH AMERICAN CONSTRUCTION GROUP, DATED 2019-02-06 (COMPILED L-L APPROVED FOUNDATIONS), 2019-02-14 (COMPILED L-L S1 BLANKET), AND 2019-02-13 (COMPILED SG1 BLANKET).
2. ACTIVE INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: CURRENTLY READING AN ACTIVE WATER LEVEL, DRY OR PLUGGED <20 m ABOVE TIP ELEVATION AS THIS COULD SHOW A RESPONSE IN THE FUTURE.
3. ASTERISK (*) DENOTES PROPOSED INSTRUMENT LOCATION TO BE UPDATED WITH AS-CONSTRUCTED LOCATION WHEN SURVEY IS COMPLETED.

SCALE 0 250 m

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA,STATEMENTS,CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

TITLE
L-L DAM
ACTIVE INCLINOMETERS
LOCATION PLAN

PROJECT No. M02341B43

FIG. No. IV-1

KCB-R-MLD

Time: 10:08:17
Date: 3/29/2019
Scale: 1:50.8(PS)
Drawing File: \\int.klohn.com\ProjData\M\VCR\M02341B43 - HVC 2018 Dam Safety Support\400 Drawings\CAD\Dam Safety Inspection\FIG_IV-1.dwg (nschwab)

NORTH ABUTMENT

I99-06

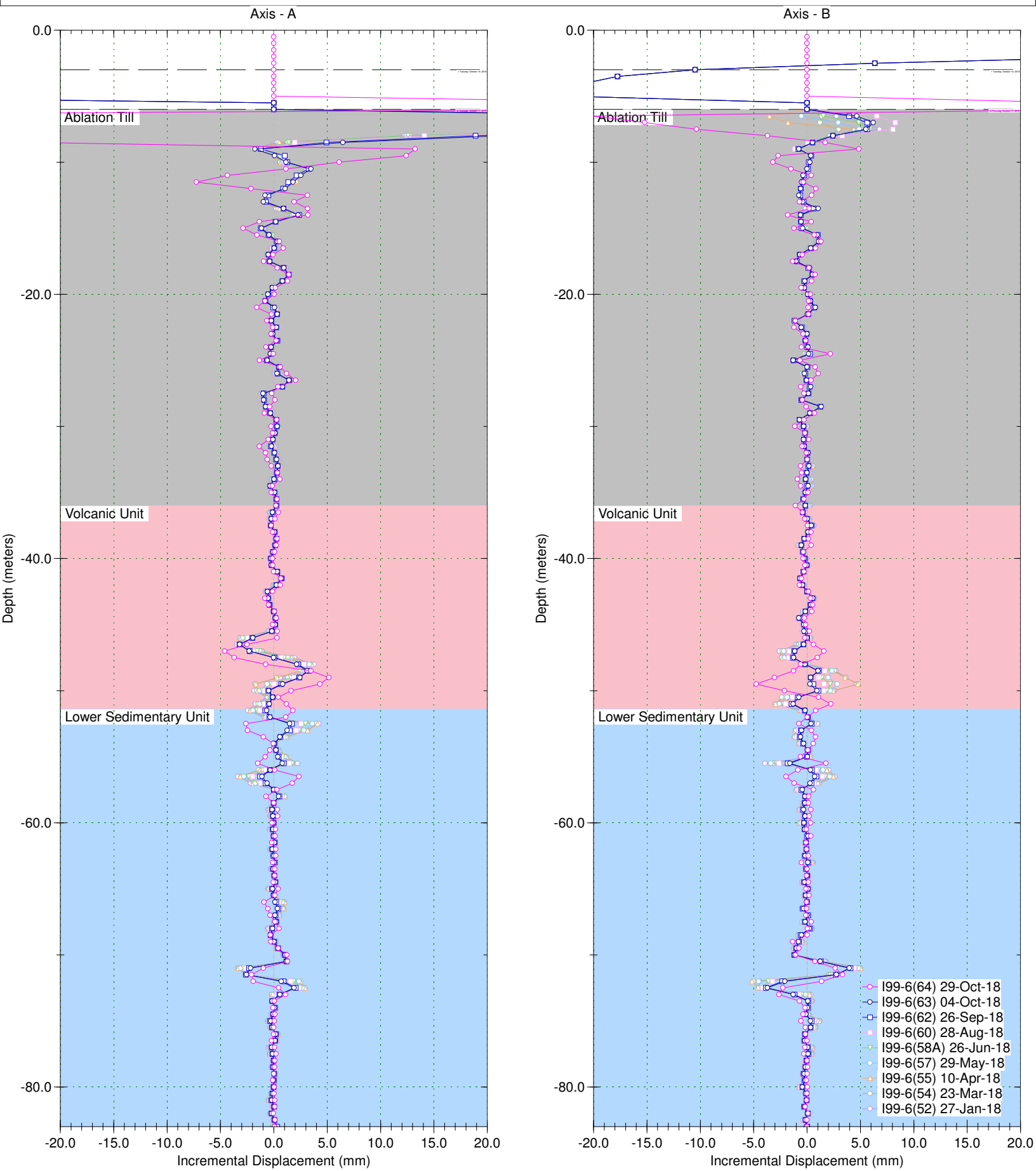
RST Instruments Ltd.

INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I99-6
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 0.00 meters
Reading Depth : 83.0 meters
A+ Groove Azimuth :
Base Reading :
Applied Azimuth : 0.0 degrees



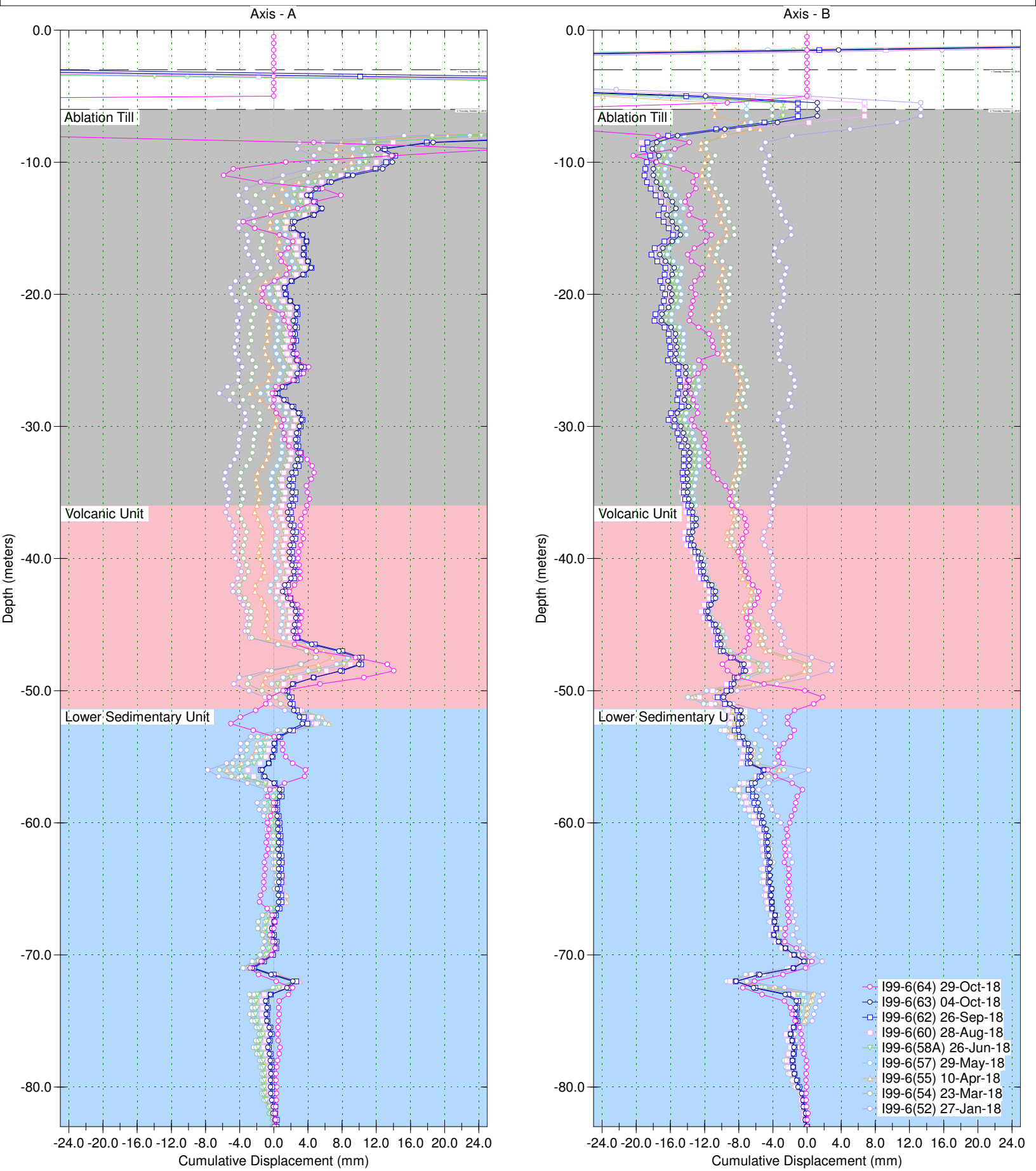
RST Instruments Ltd.

CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I99-6
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

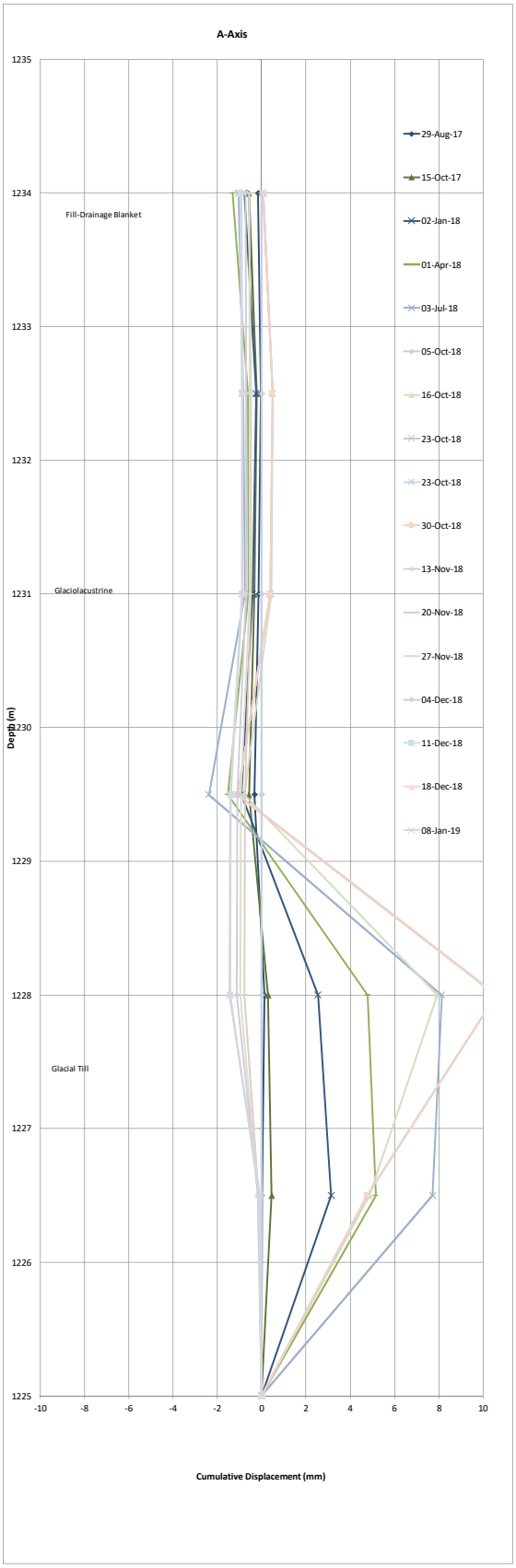
Spiral Correction : N/A
Collar Elevation : 0.00 meters
Reading Depth : 83.0 meters
A+ Groove Azimuth :
Base Reading :
Applied Azimuth : 0.0 degrees

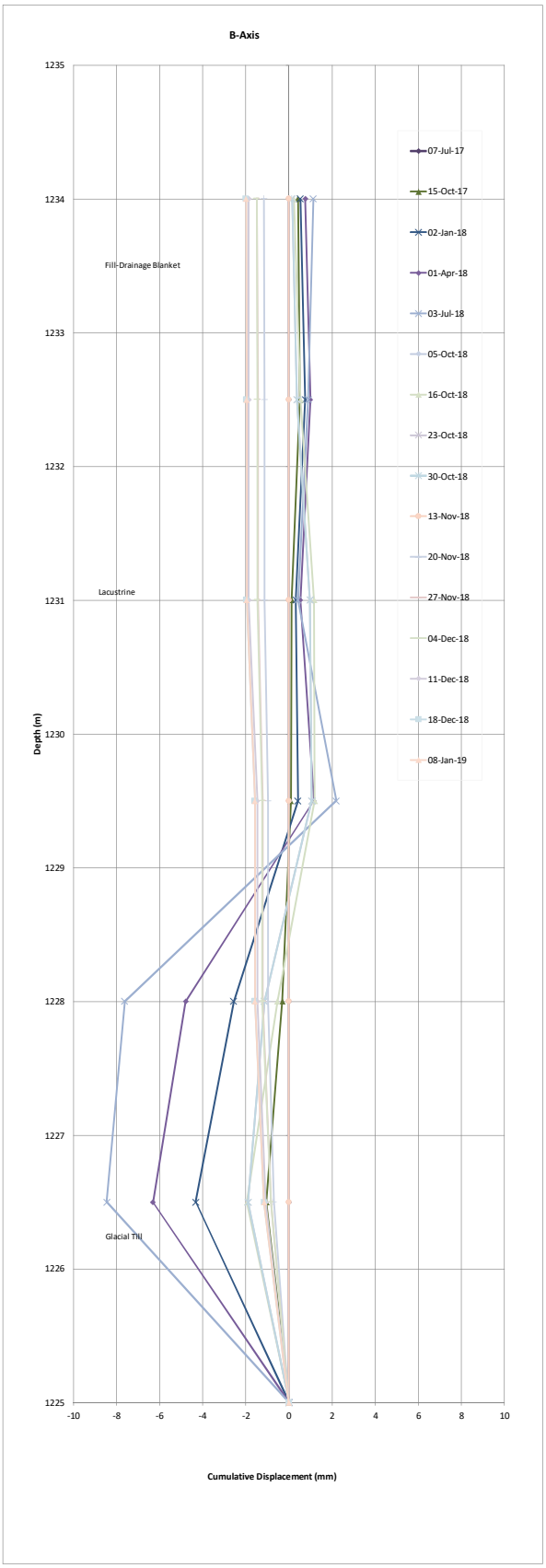


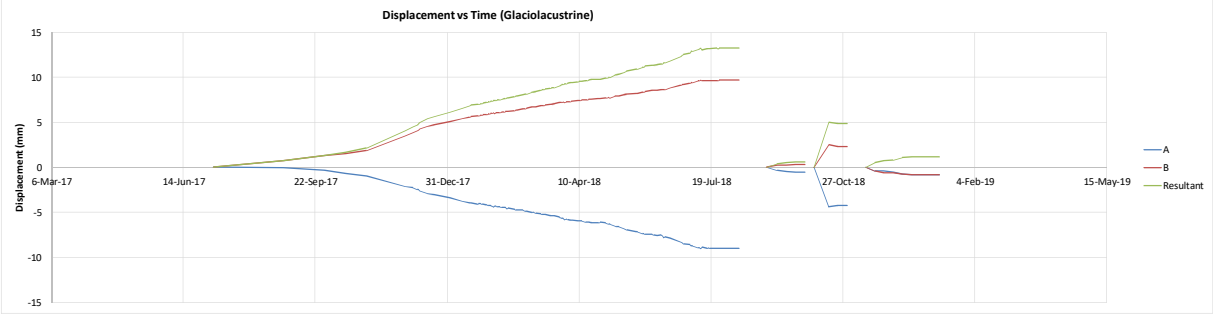
NORTH ABUTMENT

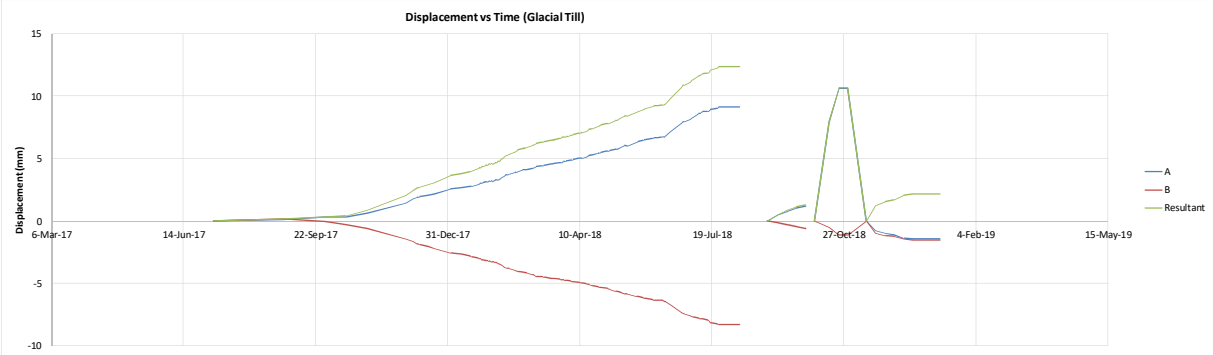
I16-01

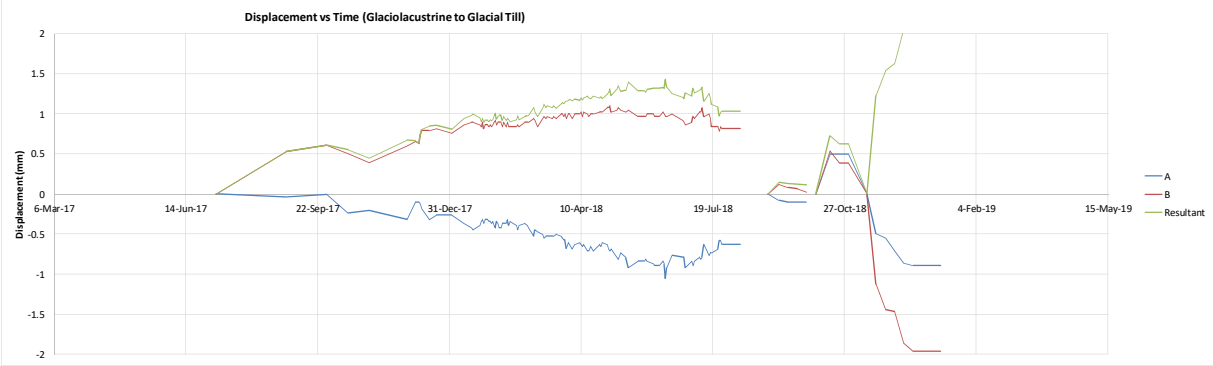
I16-1 (IPI)


A-Axis
Depth (m)
Cumulative Displacement (mm)
Fill-Drainage Blanket
Glaciolacustrine
Glacial Till
29-Aug-17
15-Oct-17
02-Jan-18
01-Apr-18
03-Jul-18
05-Oct-18
16-Oct-18
23-Oct-18
23-Oct-18
30-Oct-18
13-Nov-18
20-Nov-18
27-Nov-18
04-Dec-18
11-Dec-18
18-Dec-18
08-Jan-19


B-Axis
Depth (m)
Cumulative Displacement (mm)
Fill-Drainage Blanket
Lacustrine
Glacial Till
07-Jul-17
15-Oct-17
02-Jan-18
01-Apr-18
03-Jul-18
05-Oct-18
16-Oct-18
23-Oct-18
30-Oct-18
13-Nov-18
20-Nov-18
27-Nov-18
04-Dec-18
11-Dec-18
18-Dec-18
08-Jan-19


Displacement vs Time (Glaciolacustrine)
Displacement (mm)
15
10
5
0
-5
-10
-15
6-Mar-17
14-Jun-17
22-Sep-17
31-Dec-17
10-Apr-18
19-Jul-18
27-Oct-18
4-Feb-19
15-May-19
A
B
Resultant


Displacement vs Time (Glacial Till)
Displacement (mm)
15
10
5
0
-5
-10
6-Mar-17
14-Jun-17
22-Sep-17
31-Dec-17
10-Apr-18
19-Jul-18
27-Oct-18
4-Feb-19
15-May-19
A
B
Resultant


Displacement vs Time (Glaciolacustrine to Glacial Till)
Displacement (mm)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
6-Mar-17
14-Jun-17
22-Sep-17
31-Dec-17
10-Apr-18
19-Jul-18
27-Oct-18
4-Feb-19
15-May-19
A
B
Resultant

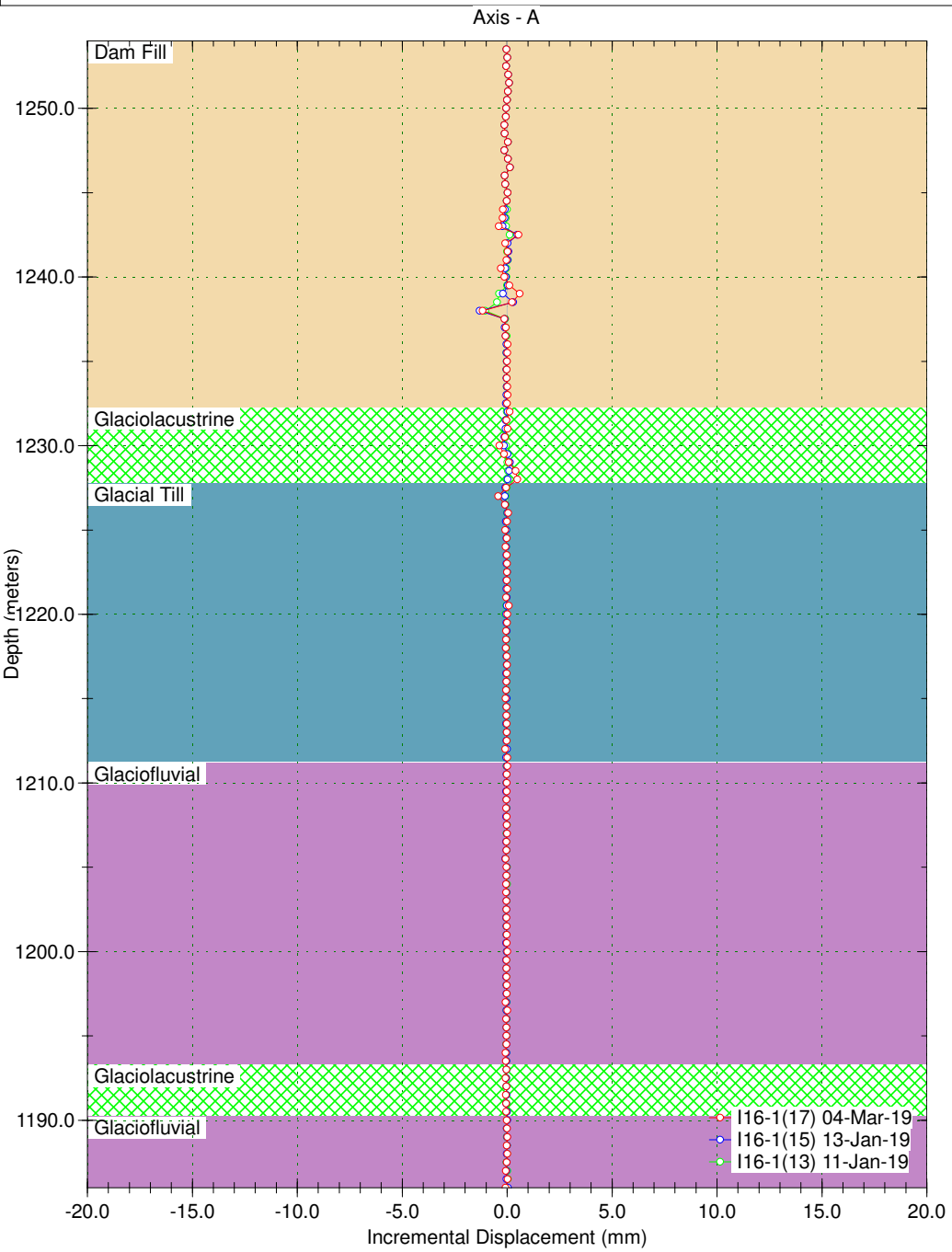
RST Instruments Ltd.

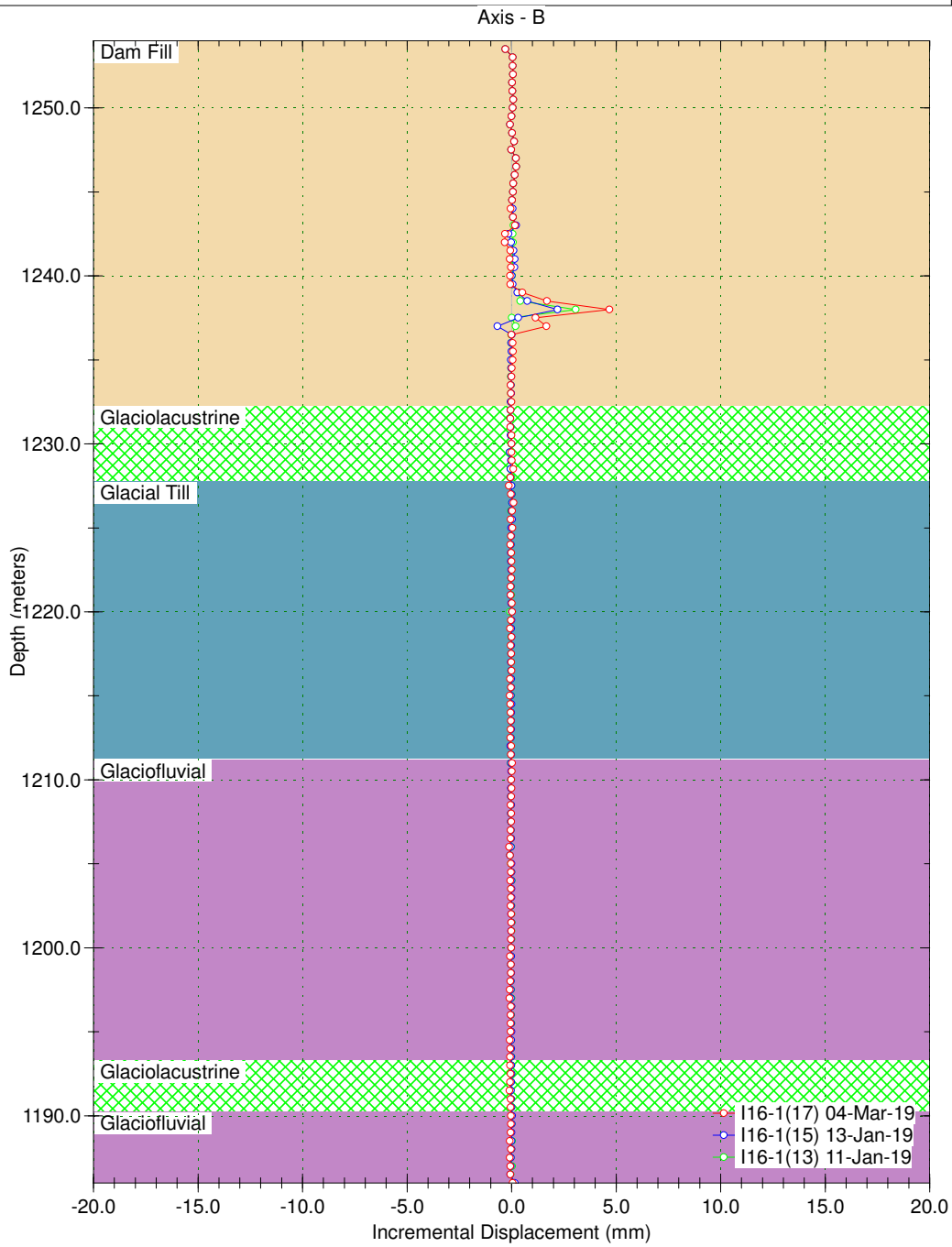
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I16-1
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1254.00 meters
Reading Depth : 68.0 meters
A+ Groove Azimuth :
Base Reading : 2019 Jan 10 11:26
Applied Azimuth : 0.0 degrees





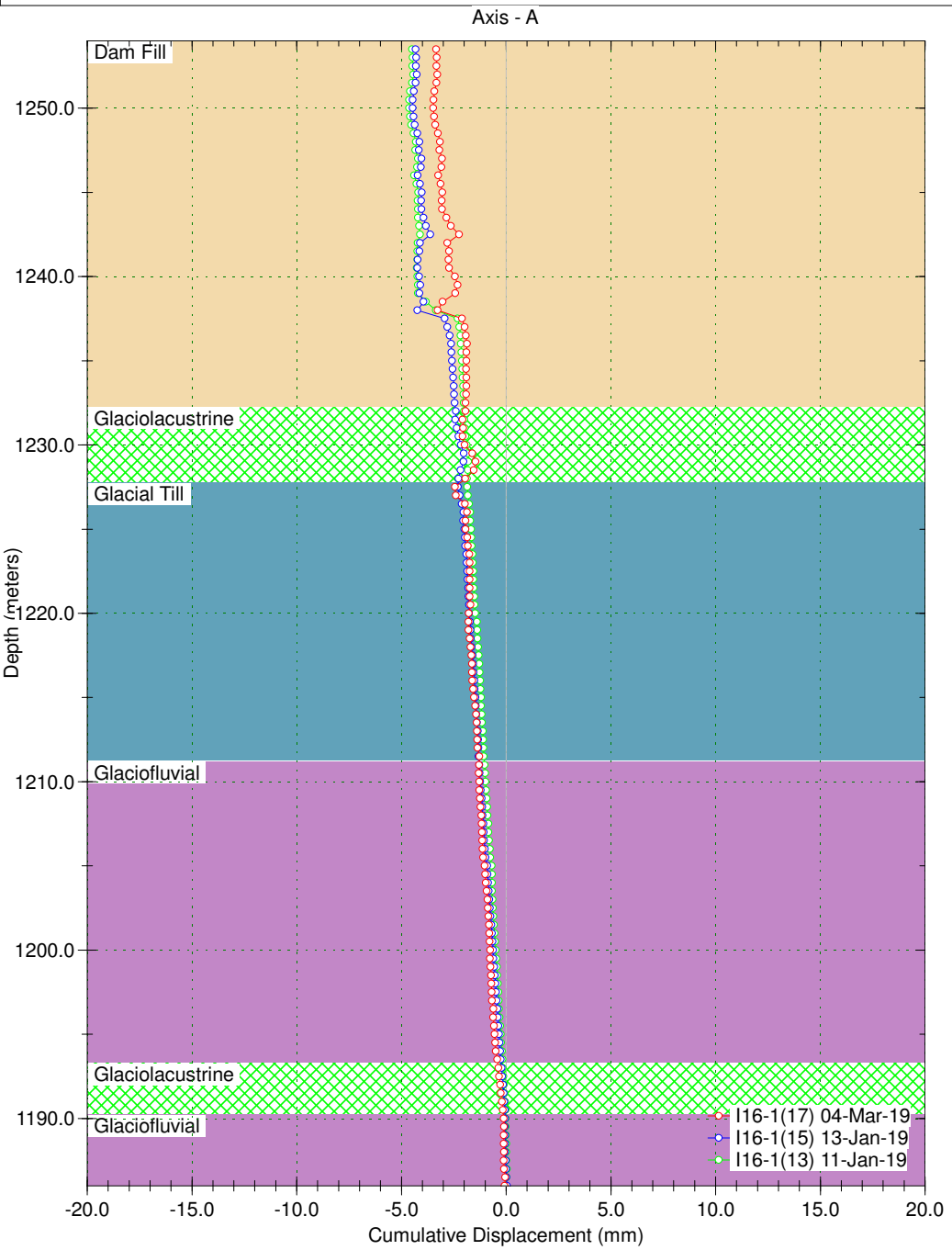
RST Instruments Ltd.

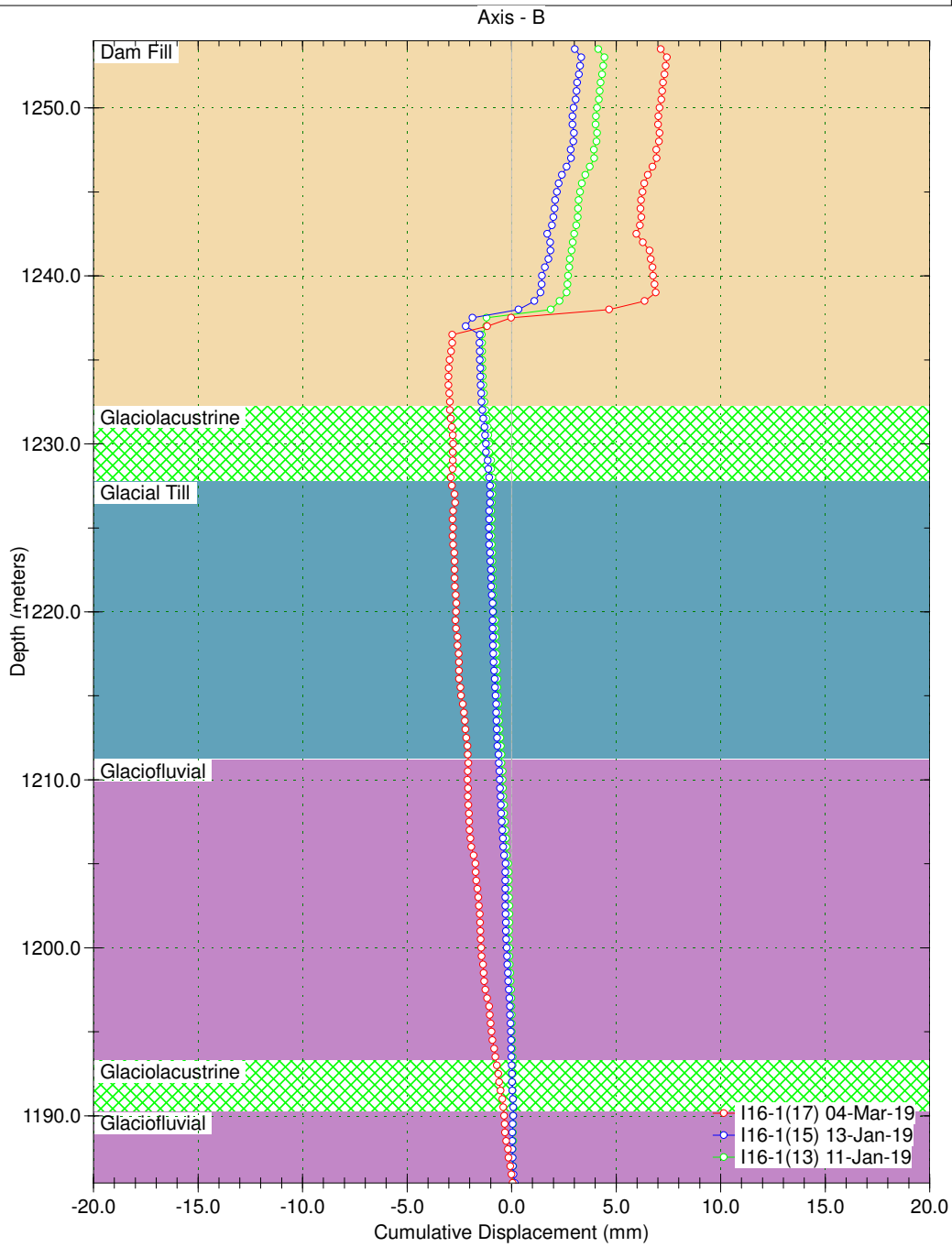
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I16-1
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1254.00 meters
Reading Depth : 68.0 meters
A+ Groove Azimuth :
Base Reading : 2019 Jan 10 11:26
Applied Azimuth : 0.0 degrees





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TIME PLOT

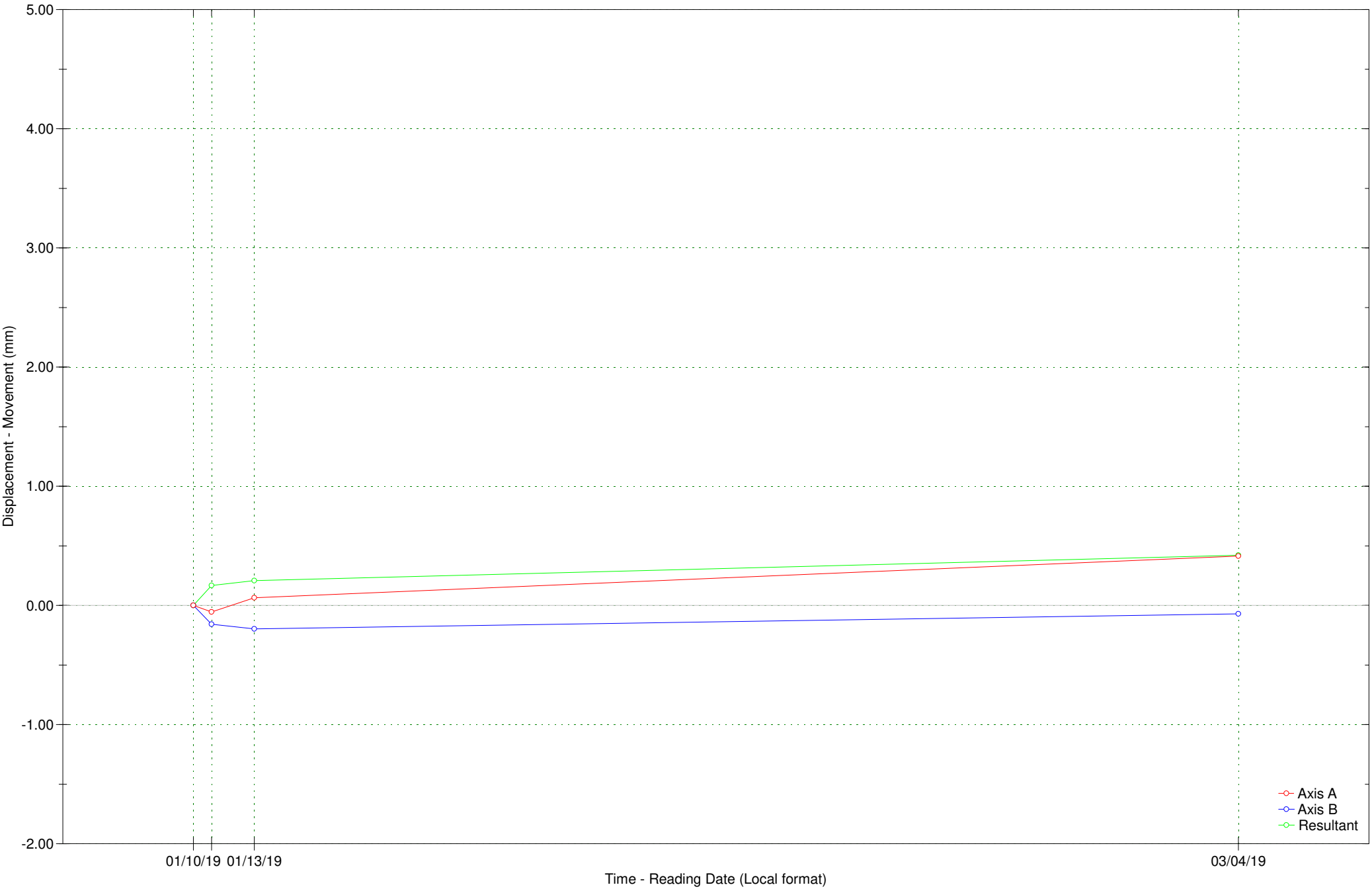
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I16-1
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1254.00 meters

Spiral Correction : N/A
Movement Depth : 24.0 - 26.5 meters
Reading Depth : 68.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Mar 04 09:41
Initial Reading : 2019 Jan 10 11:26
Applied Azimuth : 0.0 degrees

Time Plot : 24.0 - 26.5 meters



RST Instruments Ltd.

TIME PLOT

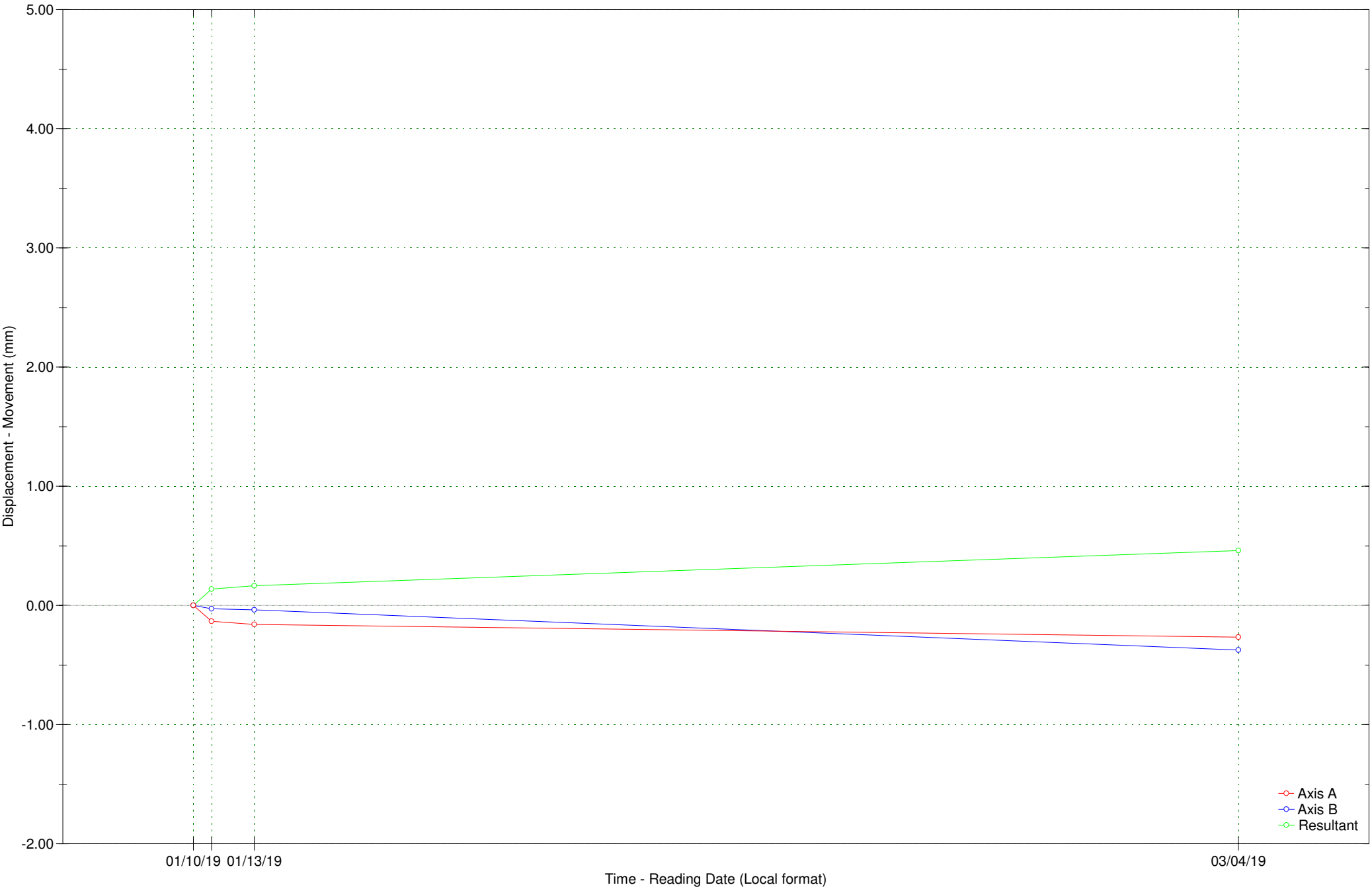
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I16-1
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1254.00 meters

Spiral Correction : N/A
Movement Depth : 61.0 - 64.0 meters
Reading Depth : 68.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Mar 04 09:41
Initial Reading : 2019 Jan 10 11:26
Applied Azimuth : 0.0 degrees

Time Plot : 61.0 - 64.0 meters



NORTH ABUTMENT

I16-04

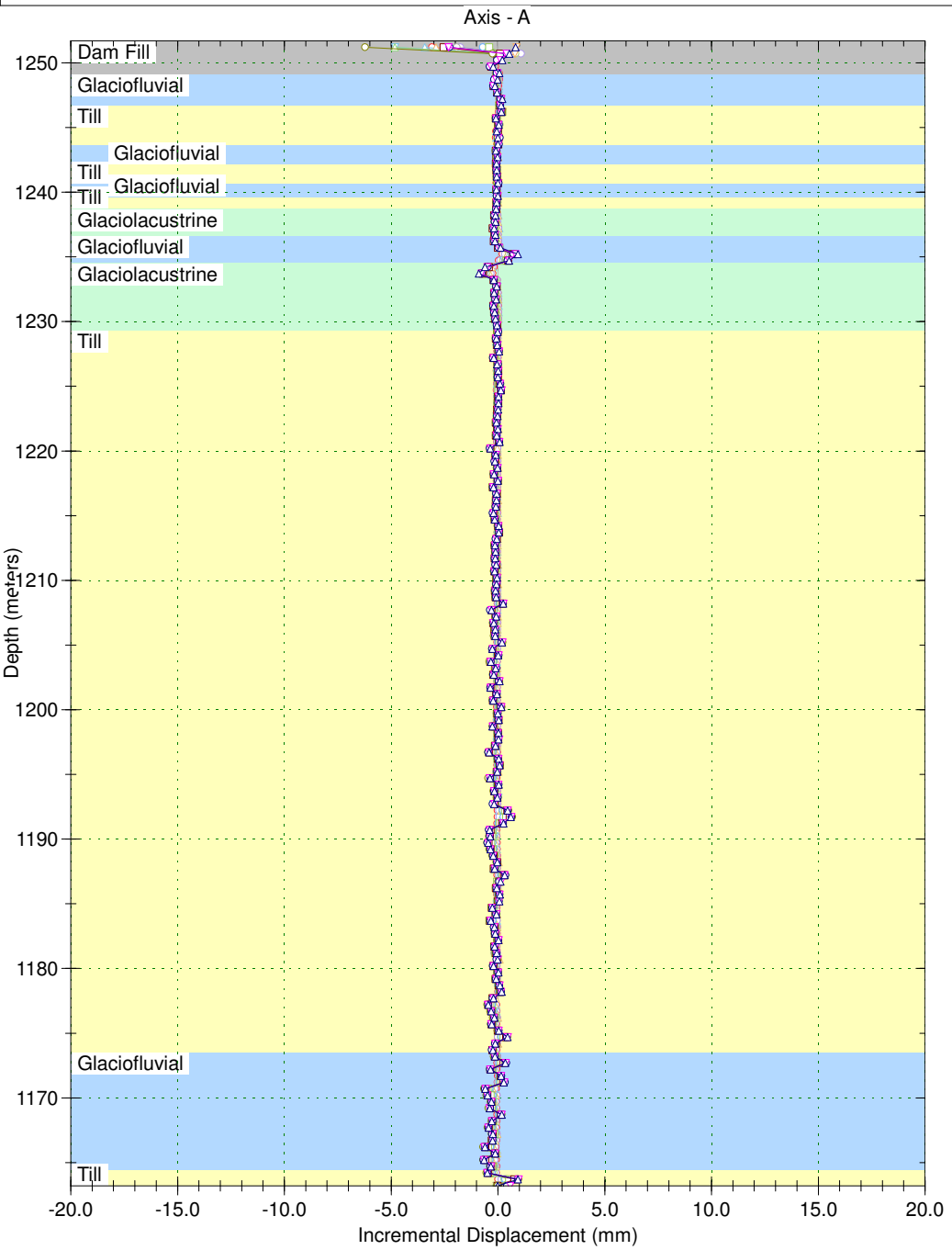
RST Instruments Ltd.

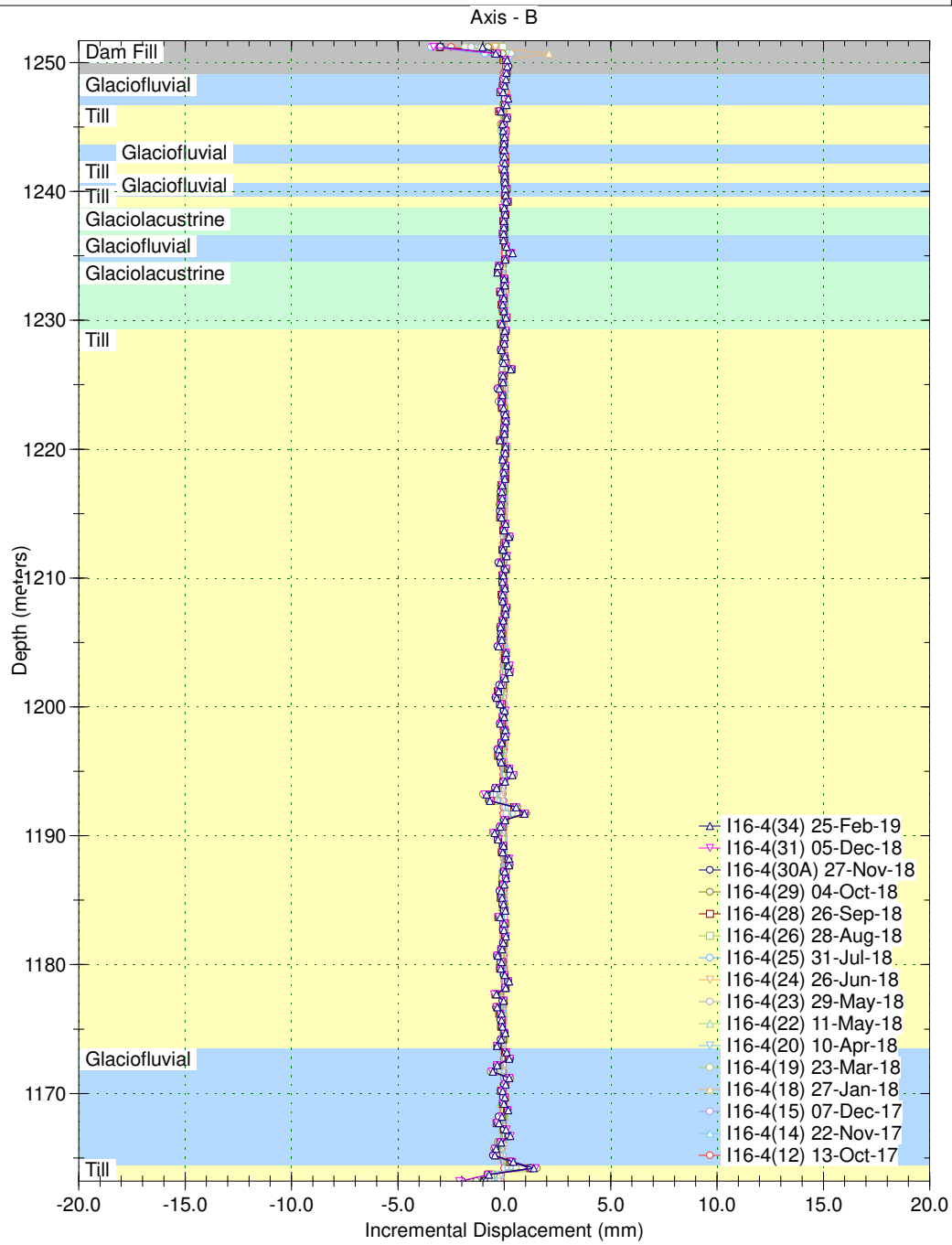
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I16-4
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1251.70 meters
Reading Depth : 88.5 meters
A+ Groove Azimuth :
Base Reading : 2017 Jul 25 10:40
Applied Azimuth : 0.0 degrees





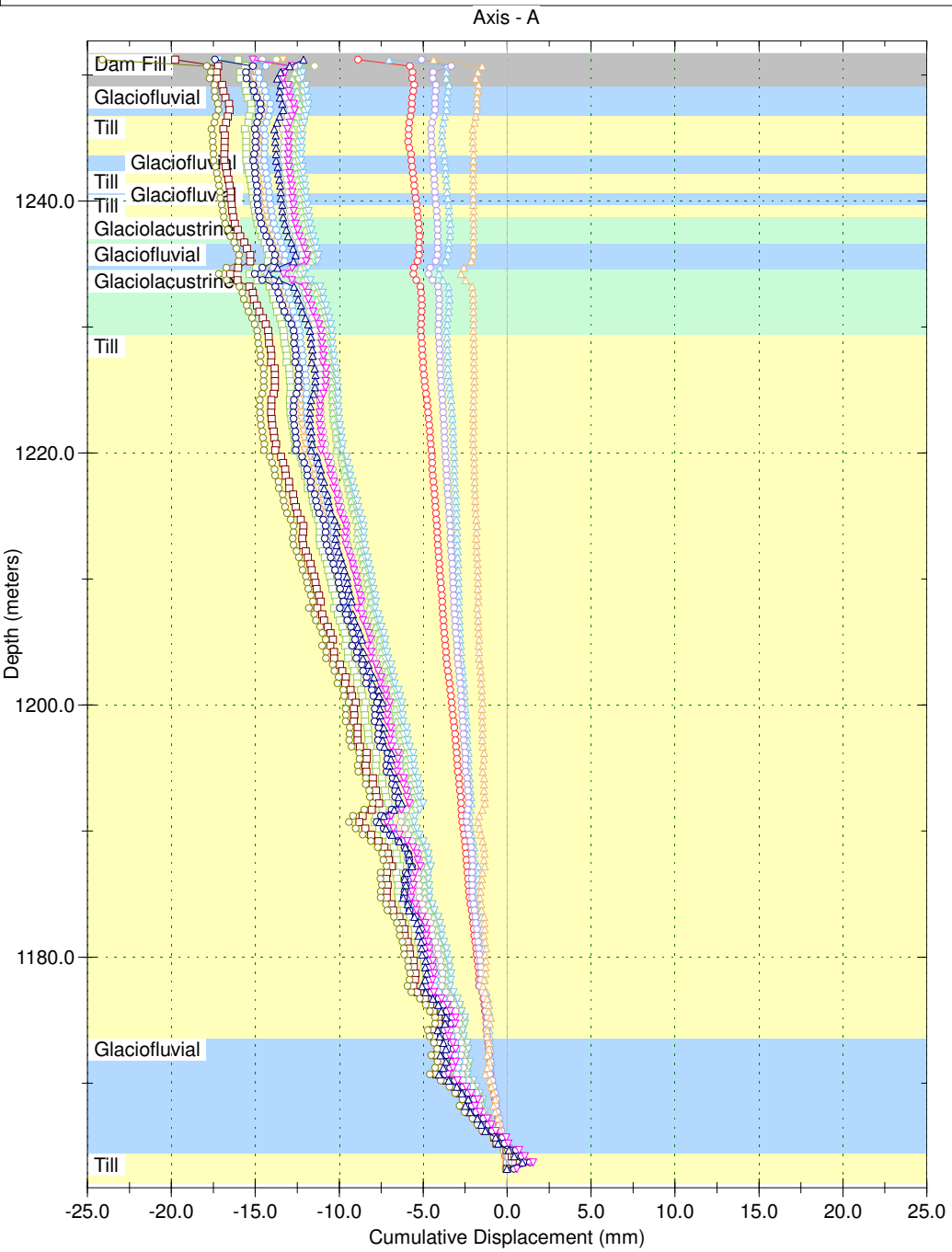
RST Instruments Ltd.

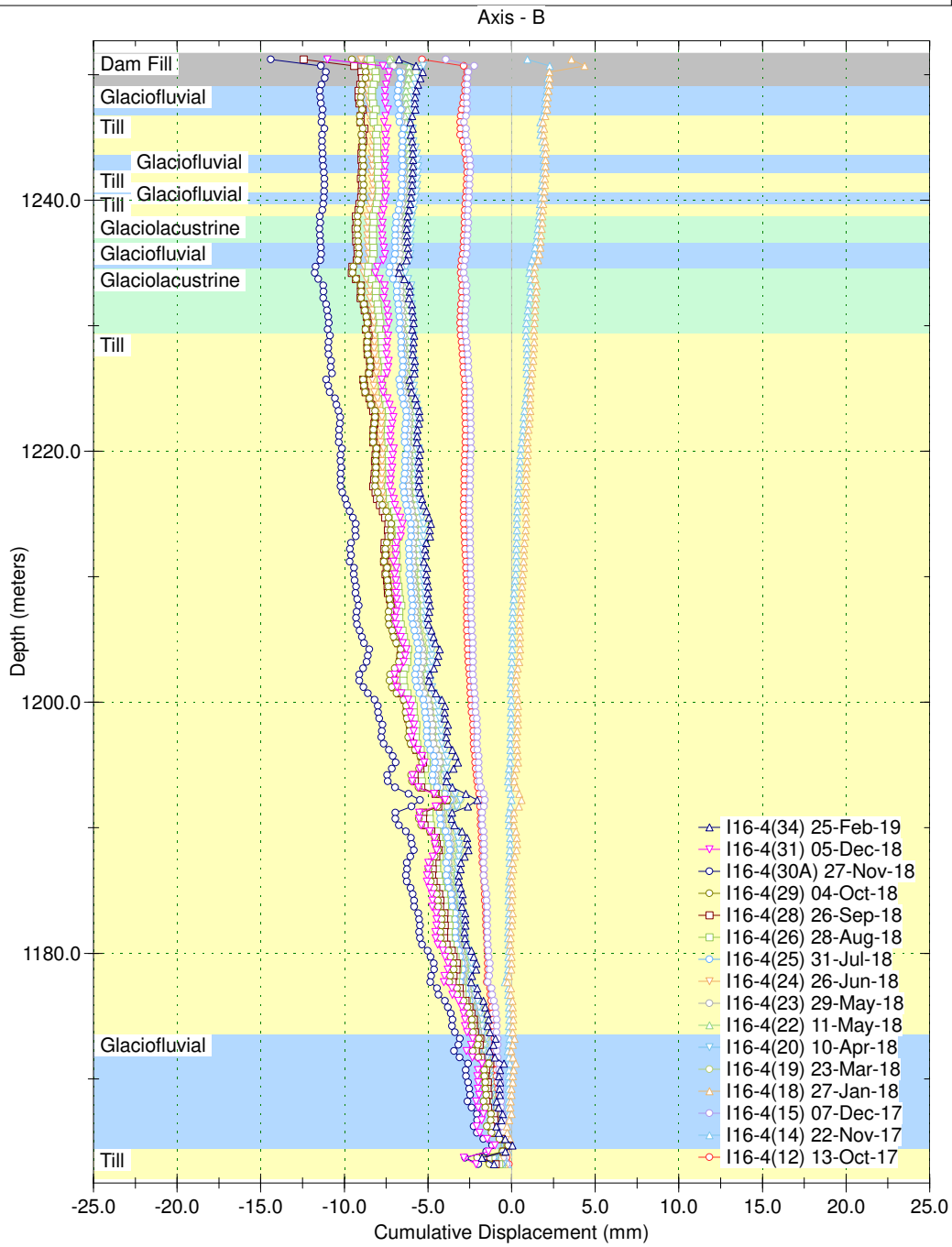
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I16-4
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1251.70 meters
Reading Depth : 88.5 meters
A+ Groove Azimuth :
Base Reading : 2017 Jul 25 10:40
Applied Azimuth : 0.0 degrees





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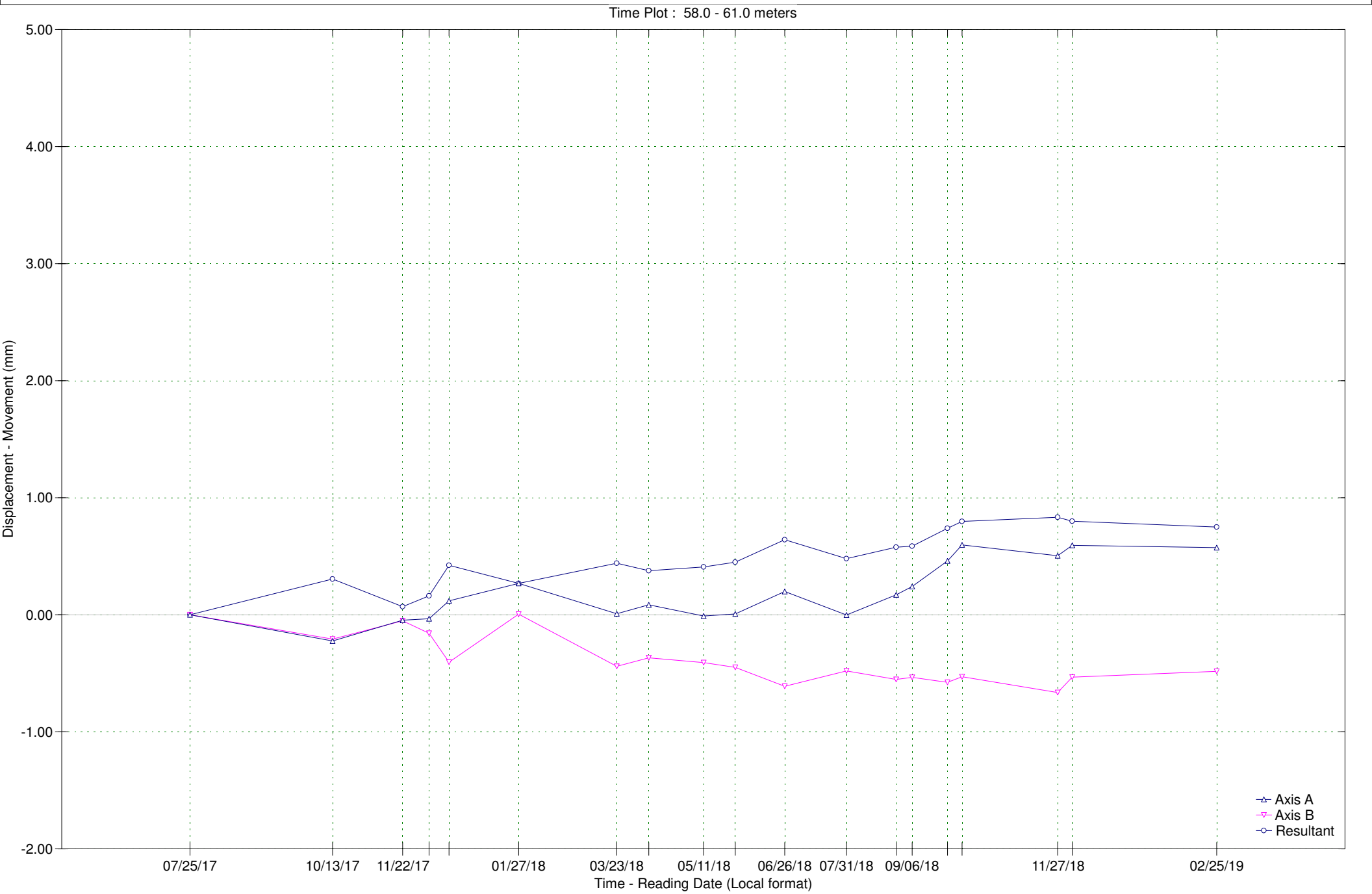
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I16-4
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1251.70 meters

Spiral Correction : N/A
Movement Depth : 58.0 - 61.0 meters
Reading Depth : 88.5 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 25 10:25
Initial Reading : 2017 Jul 25 10:40
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

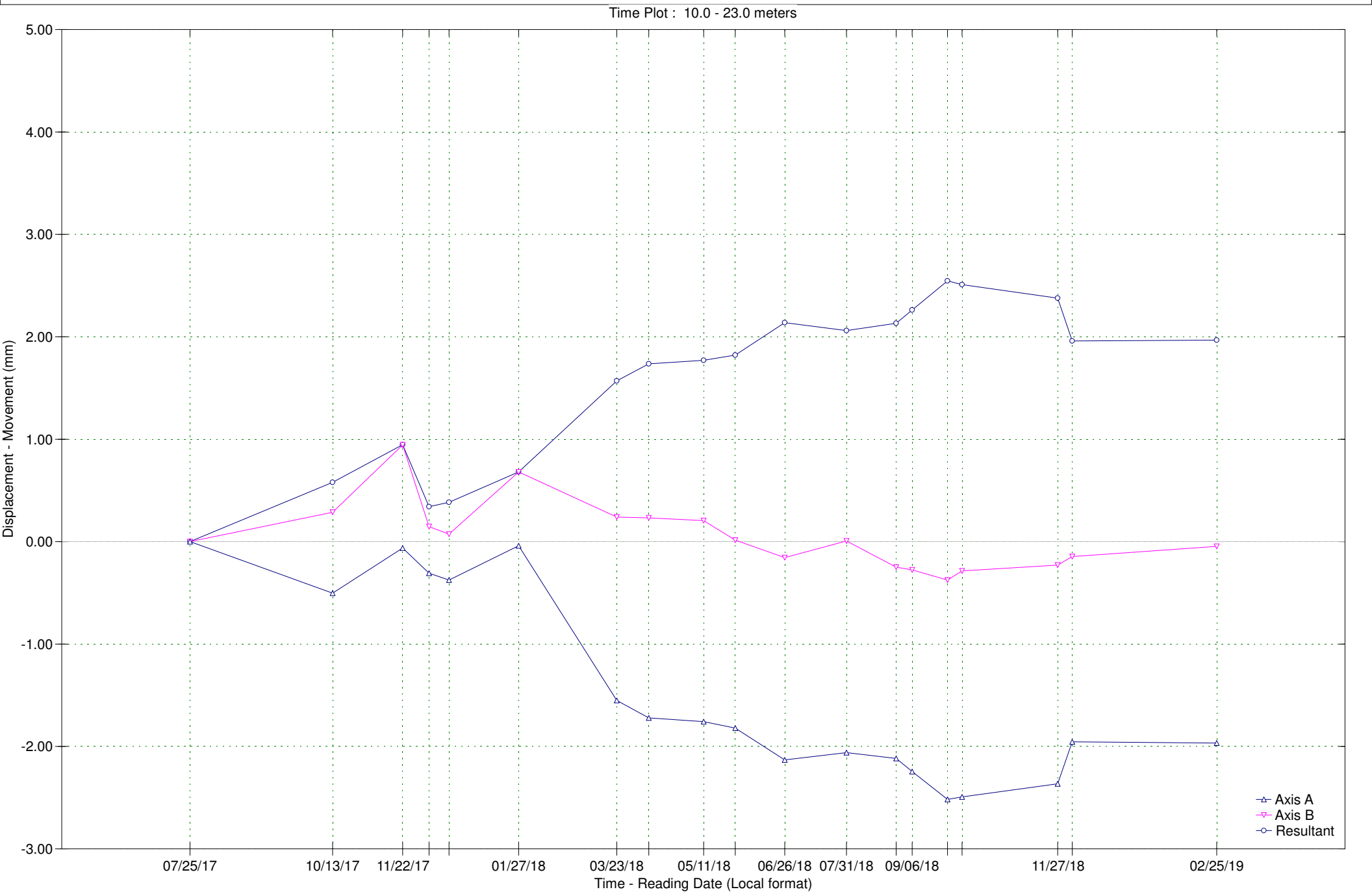
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I16-4
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1251.70 meters

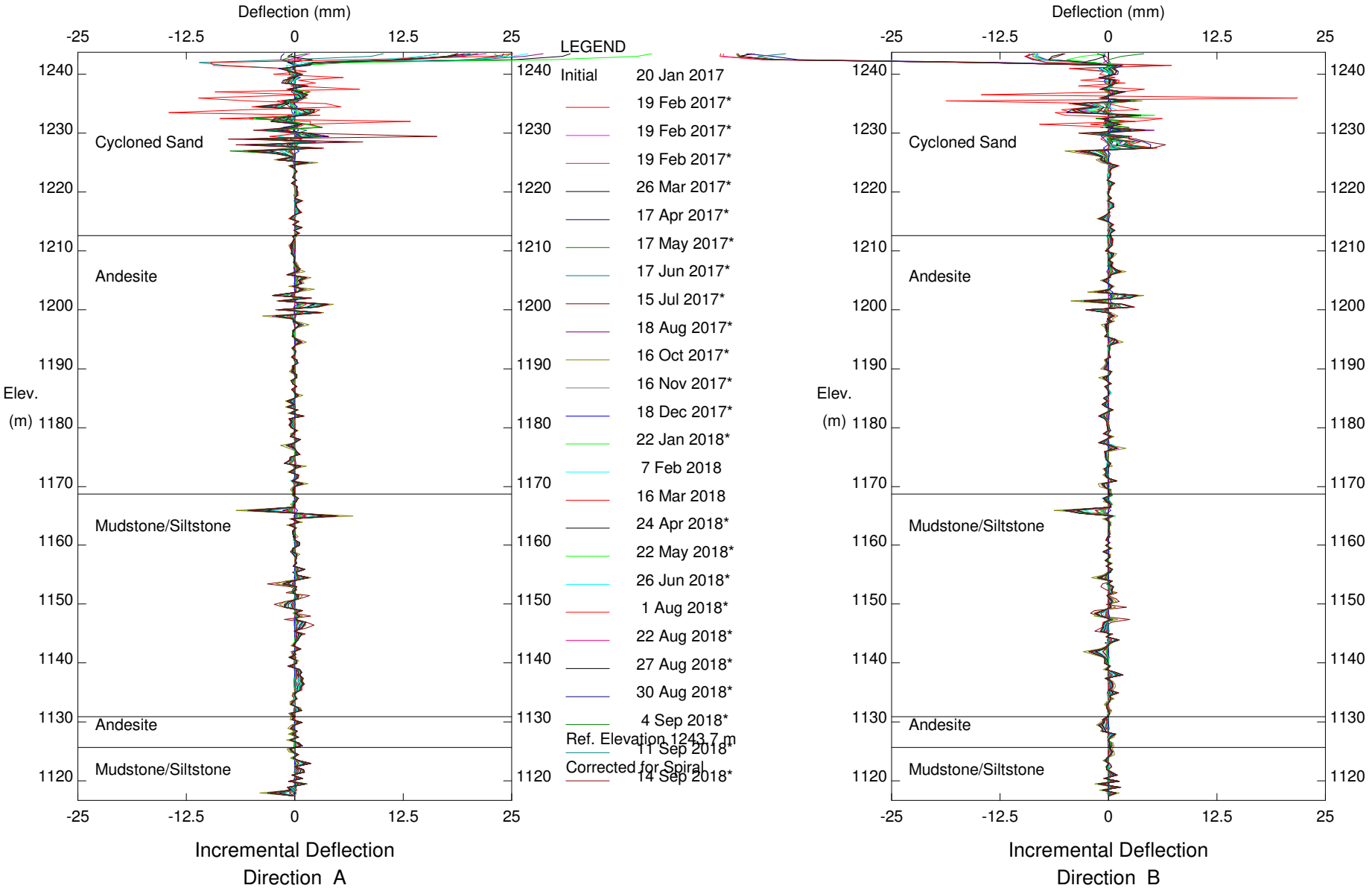
Spiral Correction : N/A
Movement Depth : 10.0 - 23.0 meters
Reading Depth : 88.5 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 25 10:25
Initial Reading : 2017 Jul 25 10:40
Applied Azimuth : 0.0 degrees



NORTH DAM

I99-05

Highland Valley Copper - Logan Lake, BC

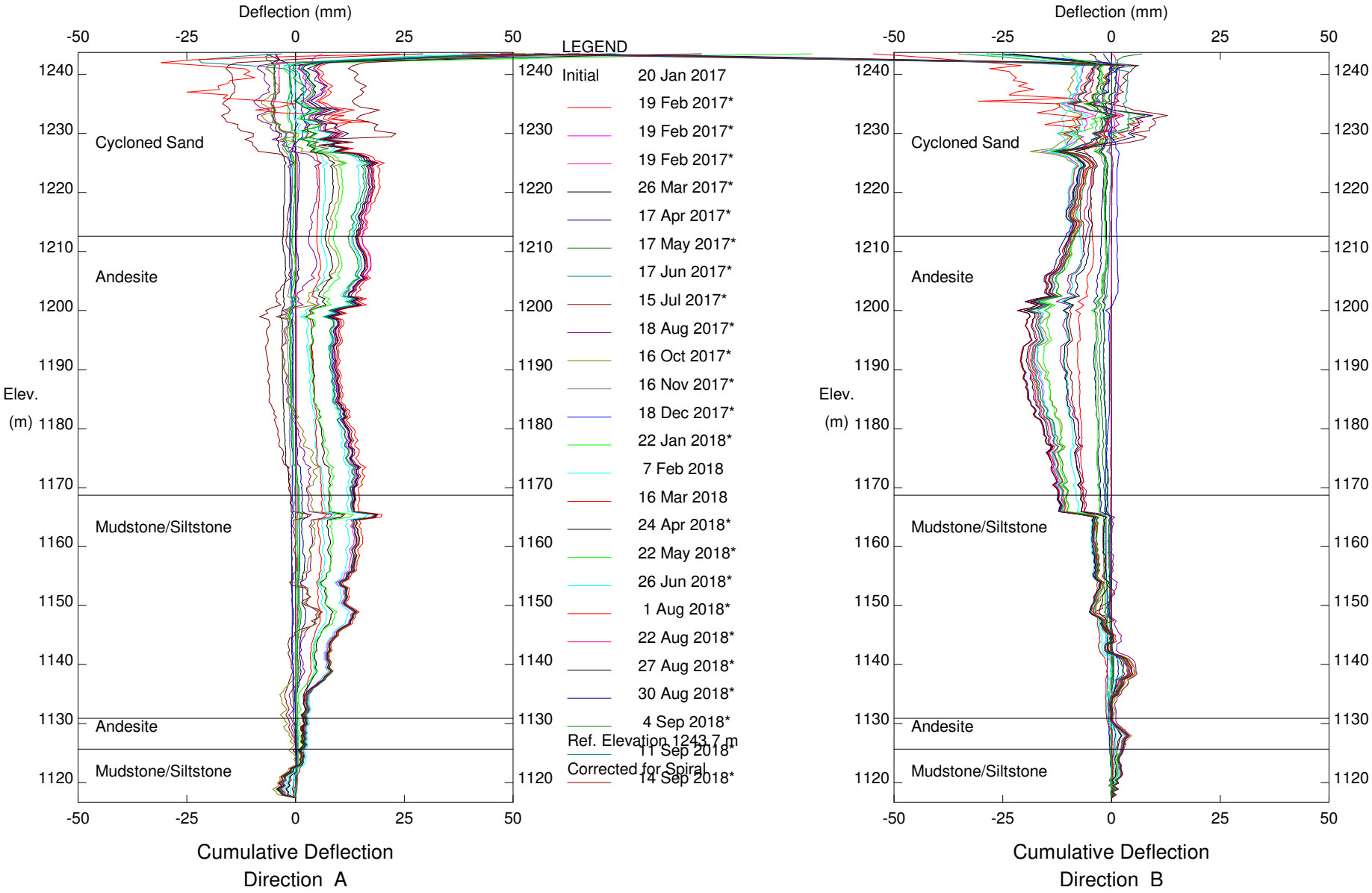


Saddle Dam, Inclinometer I99-5

Sets marked * include zero shift and/or rotation corrections.

Z:\Services_Share\Engineering_Group\PROJECTS\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\L-L Dam\SI Monitoring\Inclinalysis Files\1----Including

Highland Valley Copper - Logan Lake, BC

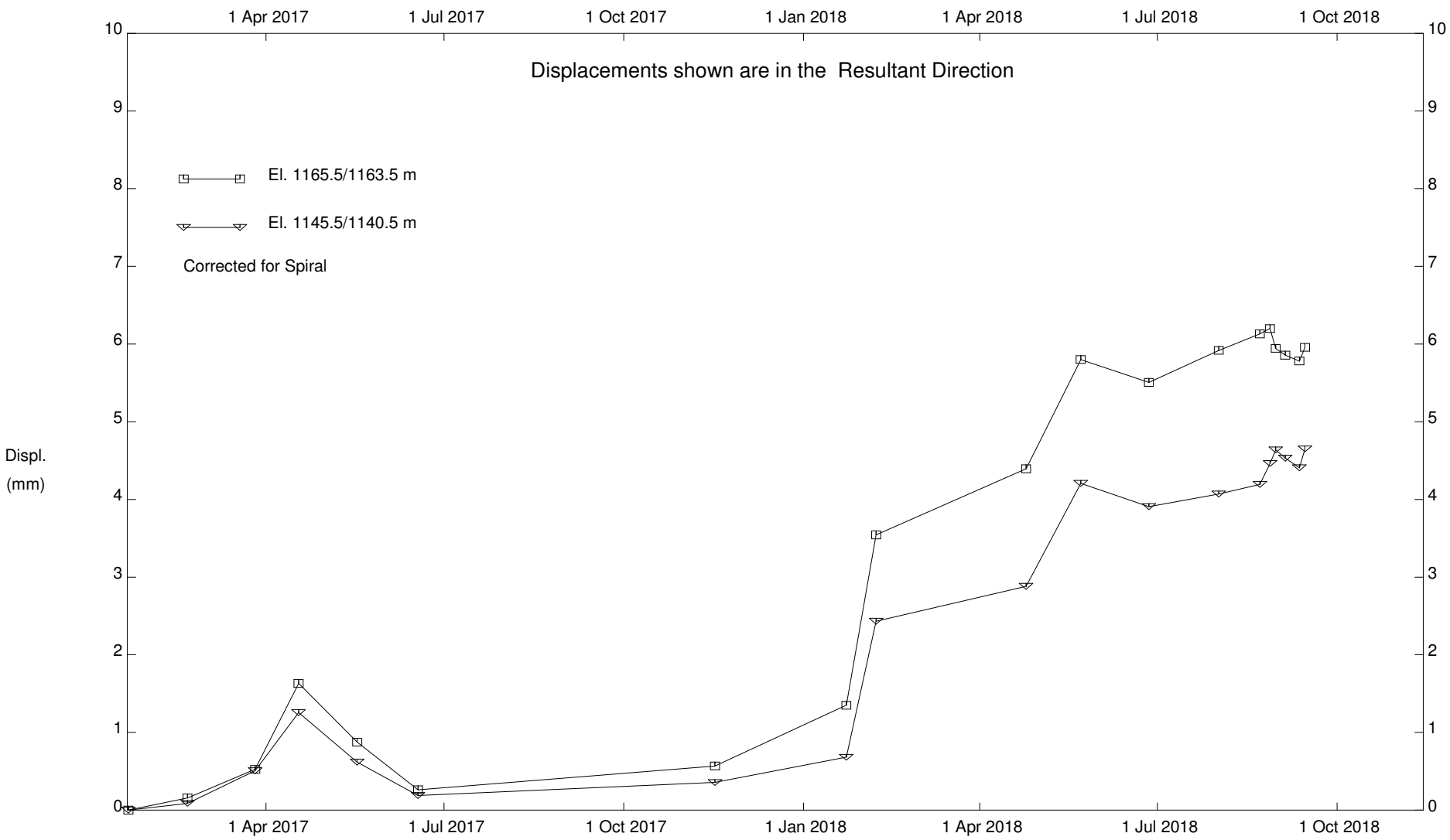


Saddle Dam, Inclinometer I99-5

Sets marked * include zero shift and/or rotation corrections.

Z:\Services_Share\Engineering_Group\PROJECTS\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\L-L Dam\SI Monitoring\Inclinalysis Files\1----Including

Highland Valley Copper - Logan Lake, BC



Saddle Dam, Inclinometer I99-5

NORTH DAM

I98-02

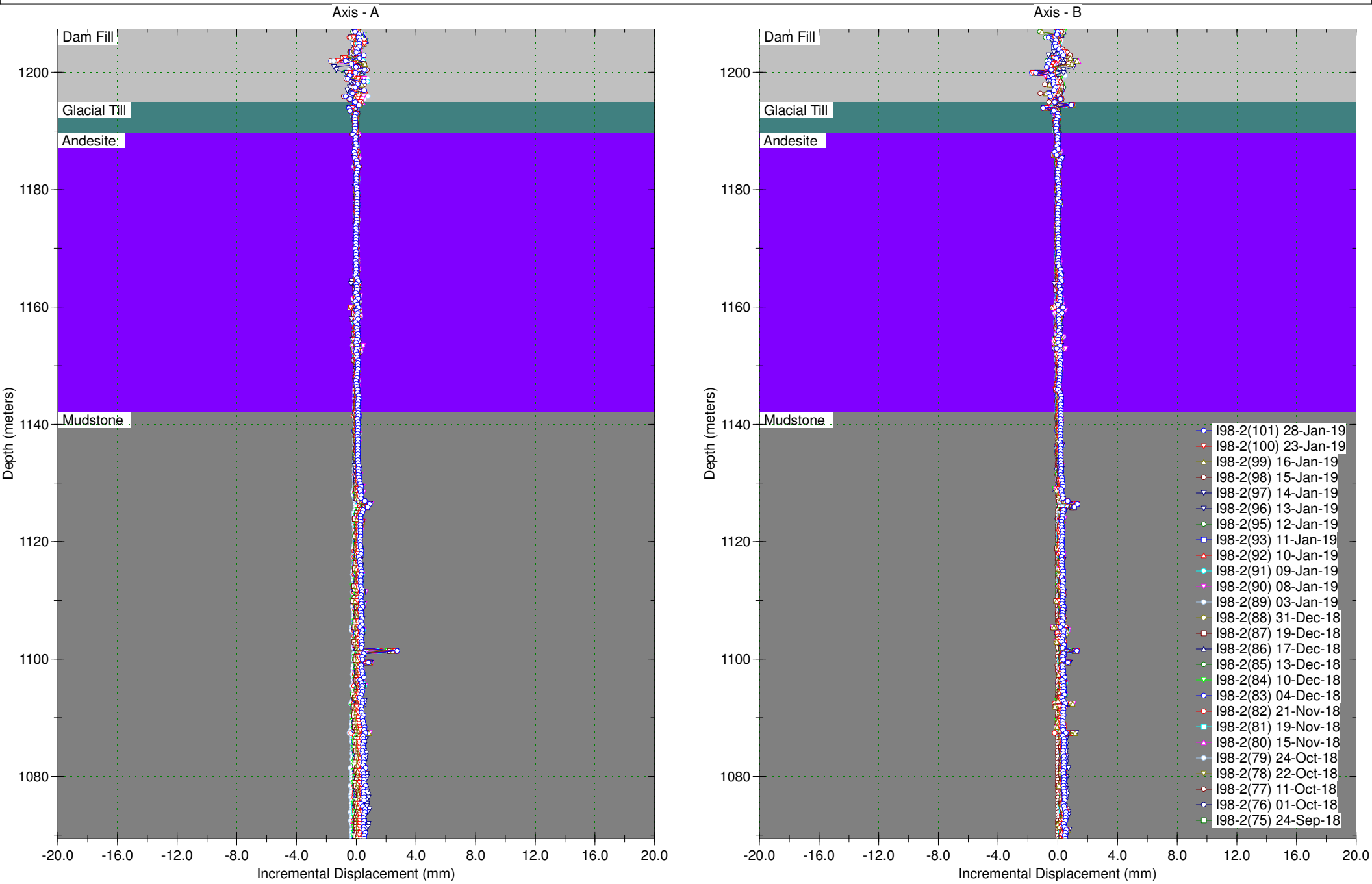
RST Instruments Ltd.

INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I98-02 Redo
Project : I98-2
Location :
Northing :
Easting :
Collar :

Spiral Correction : Enabled
Collar Elevation : :1207.40 meters
Reading Depth : 138.0 meters
A+ Groove Azimuth :
Base Reading : 2018 Sep 20 14:08
Applied Azimuth : 0.0 degrees



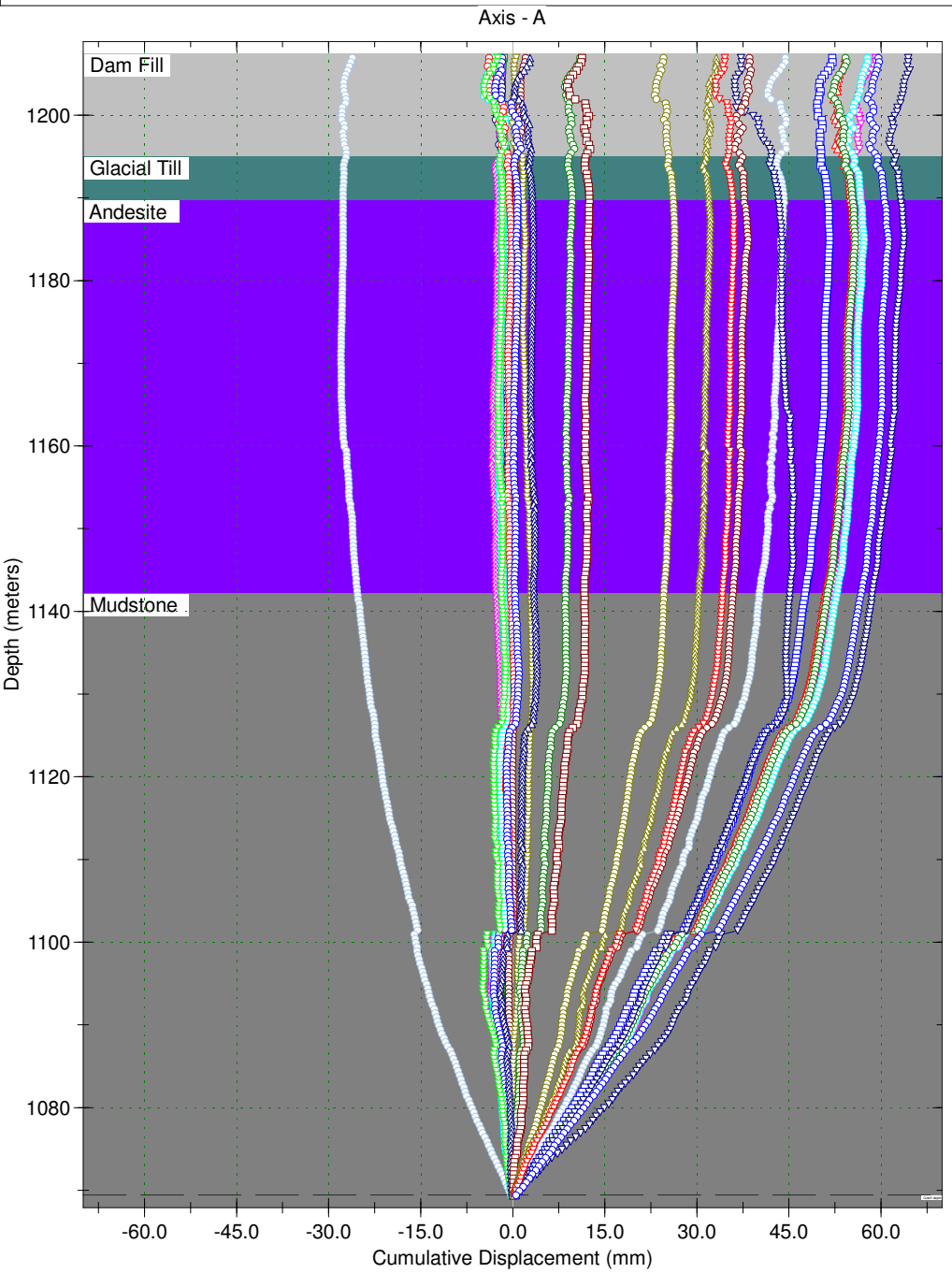
RST Instruments Ltd.

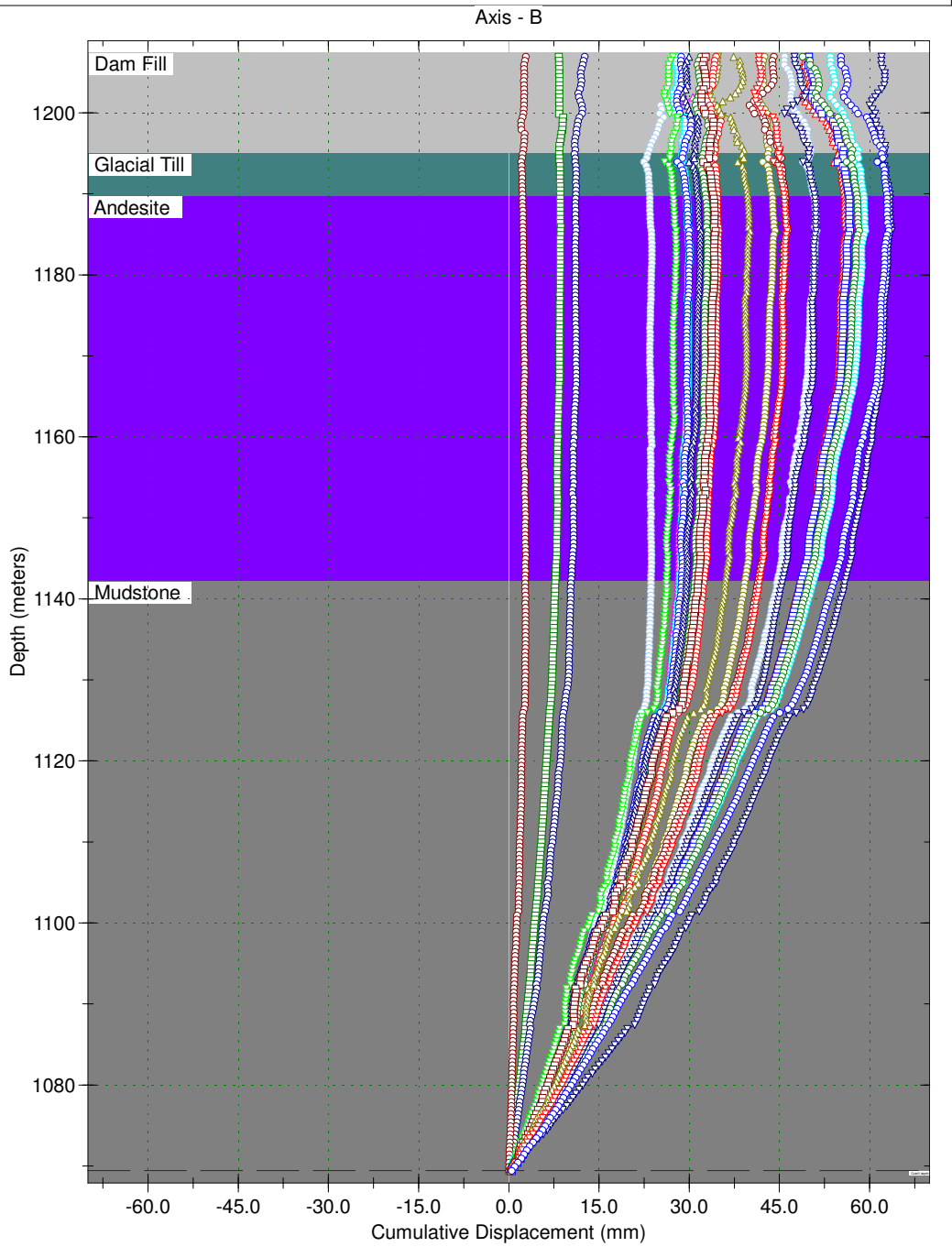
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I98-02 Redo
Project : I98-2
Location :
Northing :
Easting :
Collar :

Spiral Correction : Enabled
Collar Elevation : :1207.40 meters
Reading Depth : 138.0 meters
A+ Groove Azimuth :
Base Reading : 2018 Sep 20 14:08
Applied Azimuth : 0.0 degrees





RST Instruments Ltd.

TIME PLOT

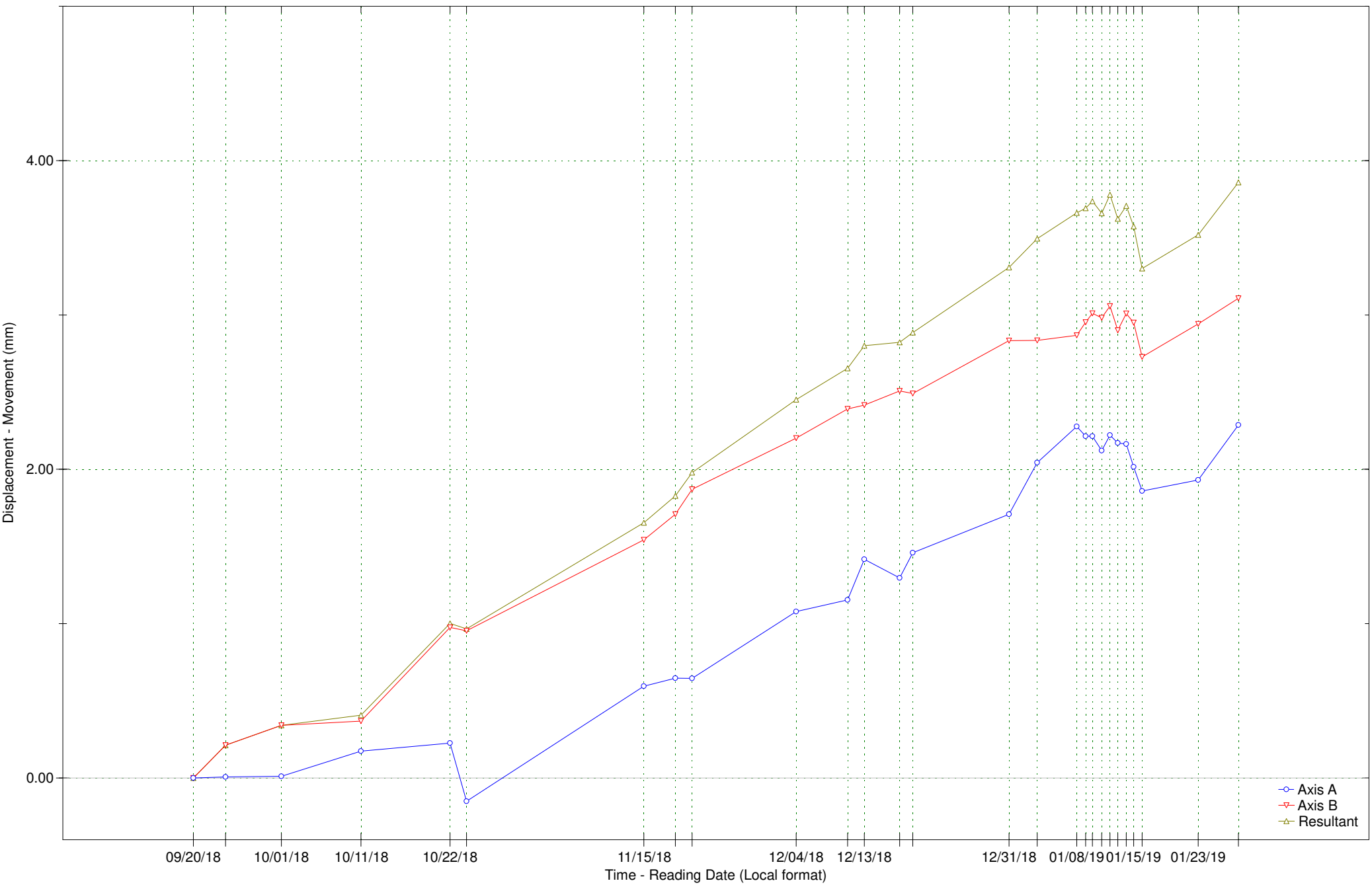
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I98-02 Redo
Project : I98-2
Location :
Northing :
Easting :
Collar :
Collar Elev : 1207.40 meters

Spiral Correction : Enabled
Movement Depth : 80.5 - 81.5 meters
Reading Depth : 138.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Jan 28 14:50
Initial Reading : 2018 Sep 20 14:08
Applied Azimuth : 0.0 degrees

Time Plot : 80.5 - 81.5 meters



RST Instruments Ltd.

TIME PLOT

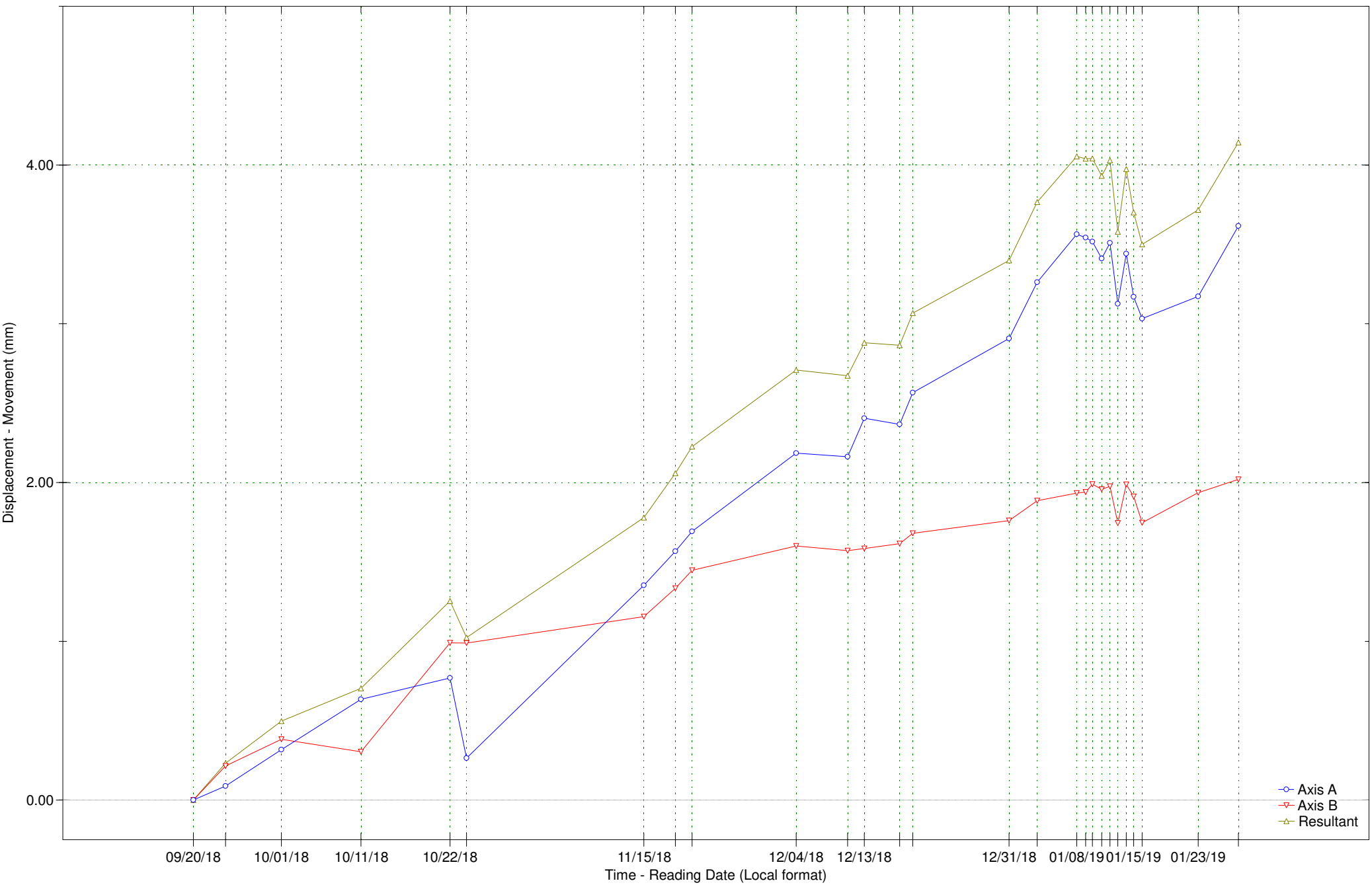
Displacement vs. Time

Inclinalysis v. 2.48.7

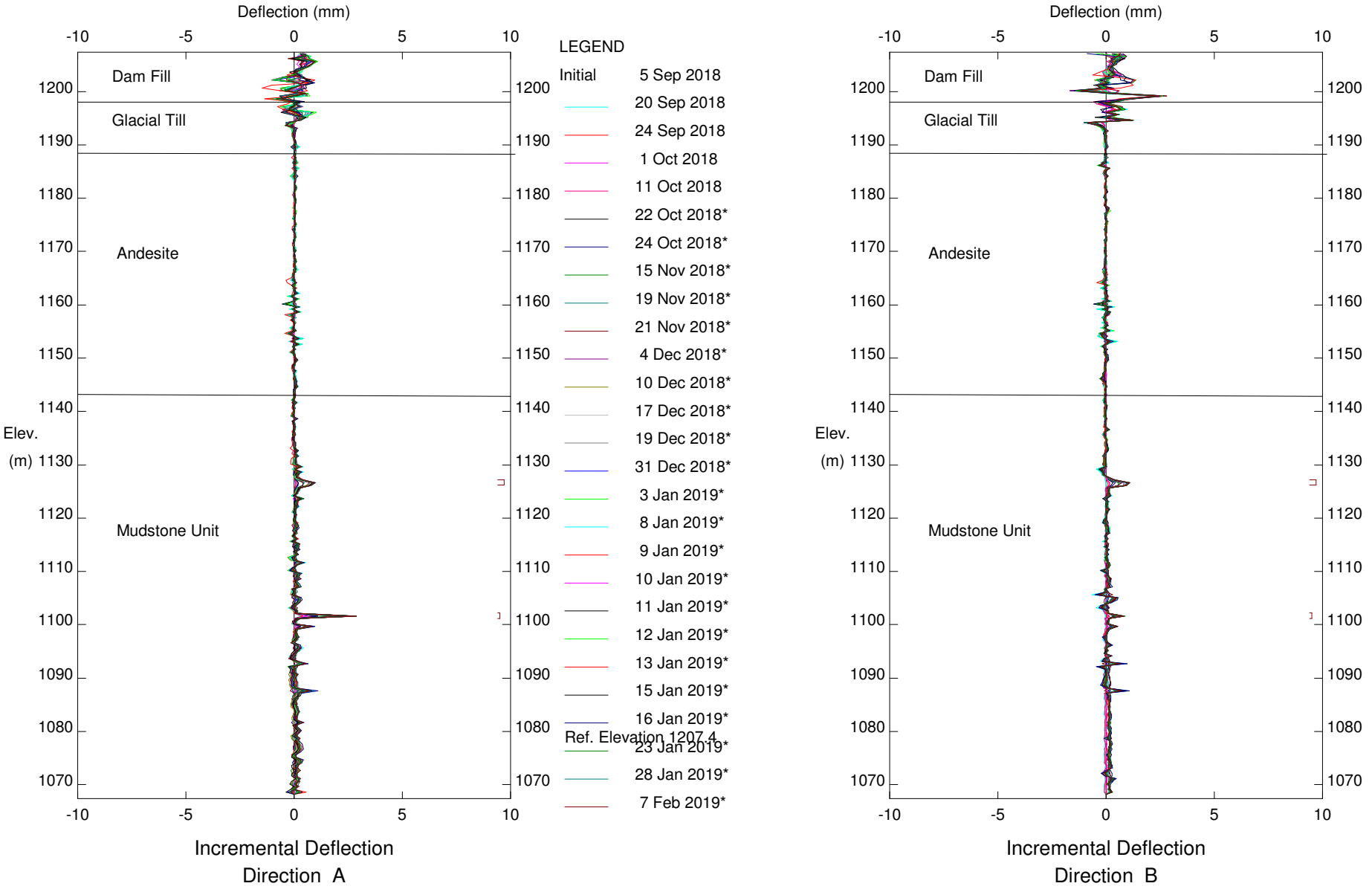
Borehole : I98-02 Redo
Project : I98-2
Location :
Northing :
Easting :
Collar :
Collar Elev : 1207.40 meters

Spiral Correction : Enabled
Movement Depth : 105.5 - 106.5 meters
Reading Depth : 138.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Jan 28 14:50
Initial Reading : 2018 Sep 20 14:08
Applied Azimuth : 0.0 degrees

Time Plot : 105.5 - 106.5 meters



Highland Valley Copper - Logan Lake, BC

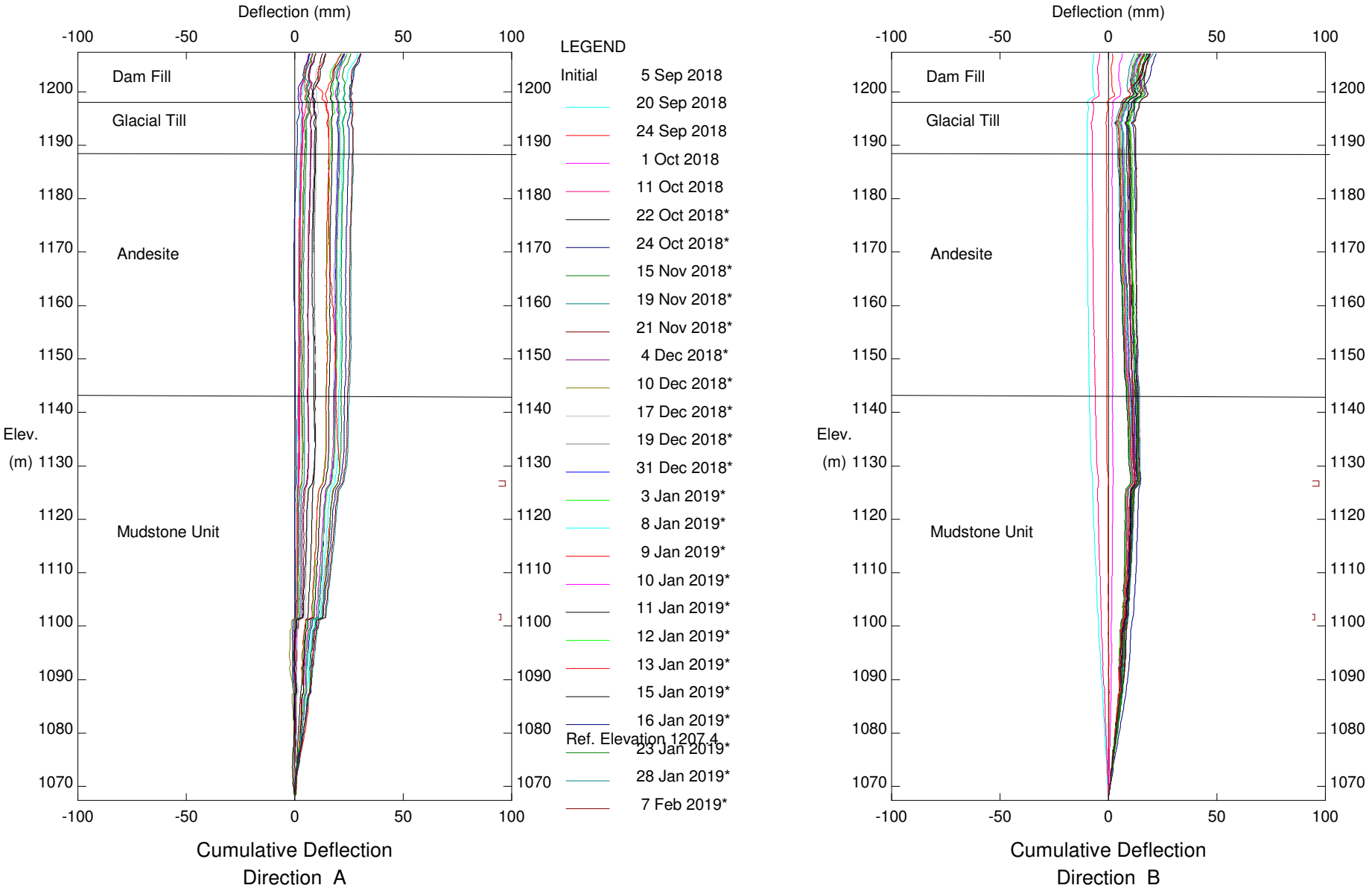


LL Dam - Dam fill excluded, Inclinometer I98-2

Sets marked * include zero shift and/or rotation corrections.

C:\Users\gafriyie\Documents\GTPlus32\I98-2\I98-2.gtl

Highland Valley Copper - Logan Lake, BC

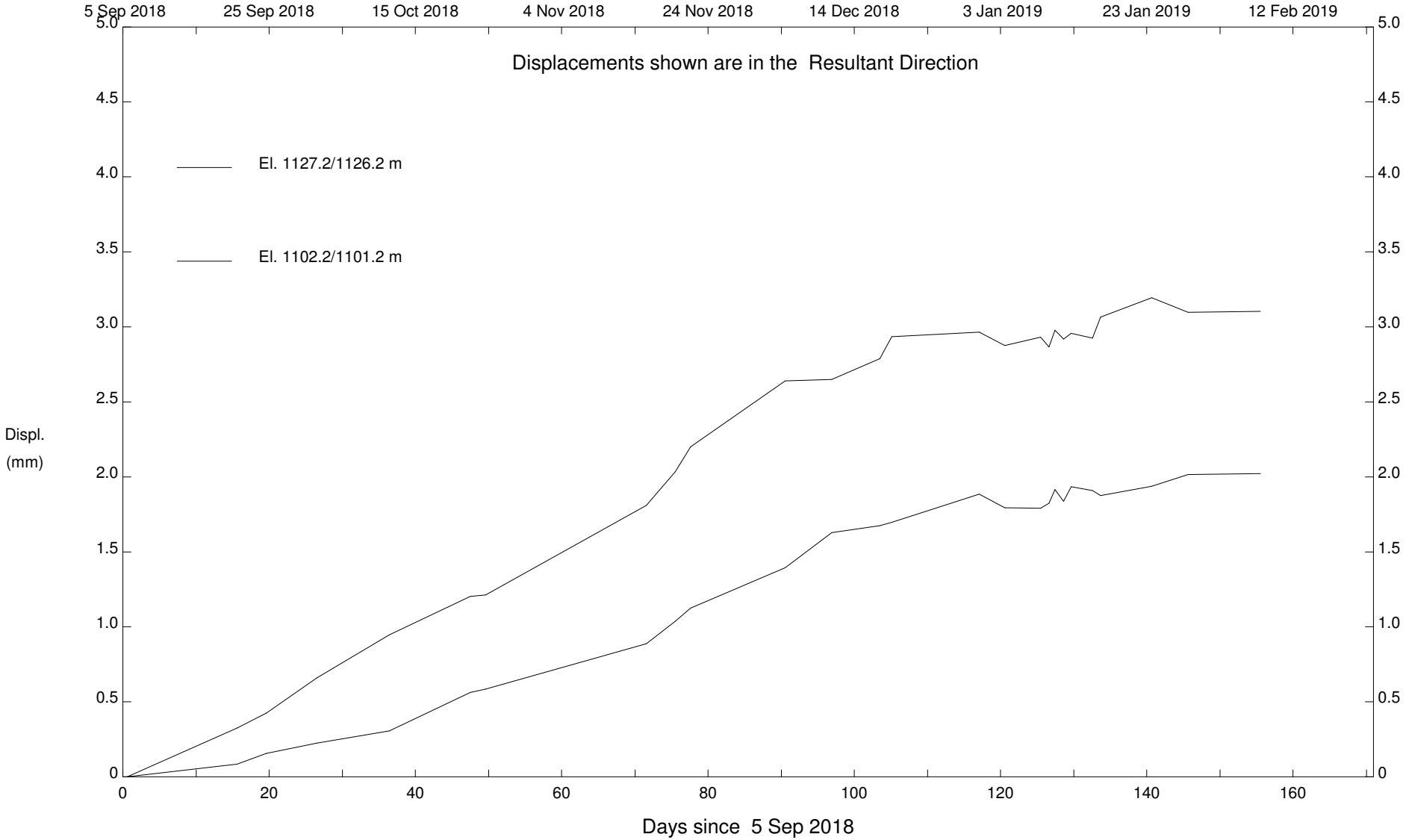


LL Dam - Dam fill excluded, Inclinometer I98-2

Sets marked * include zero shift and/or rotation corrections.

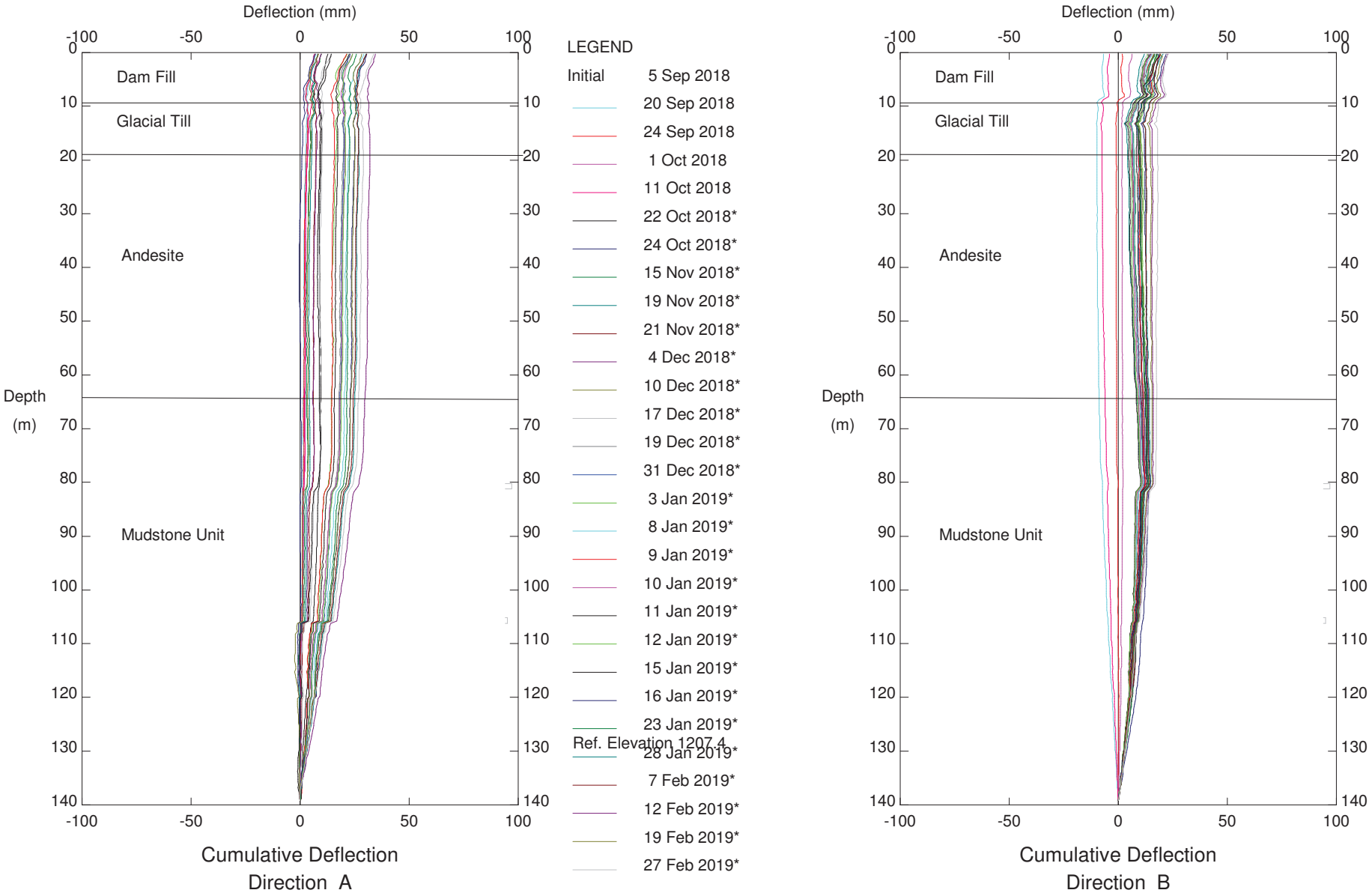
C:\Users\gafriyie\Documents\GTPlus32\I98-2\I98-2.gtl

Highland Valley Copper - Logan Lake, BC



LL Dam - Dam fill excluded, Inclinometer I98-2

Highland Valley Copper - Logan Lake, BC

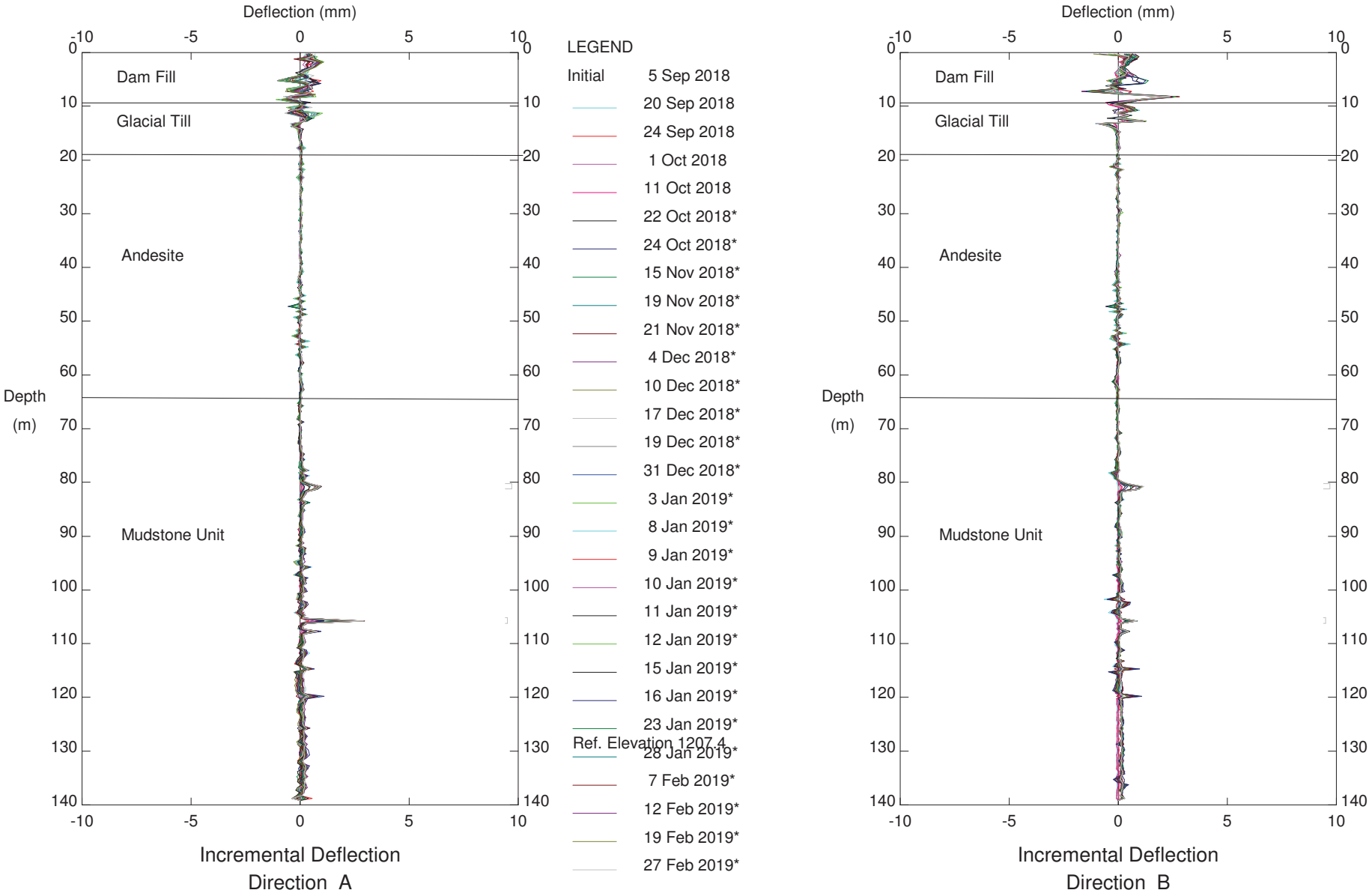


LL Dam - Dam fill excluded, Inclinometer I98-2

Sets marked * include zero shift and/or rotation corrections.

V:\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\L-L Dam\SI Monitoring\Inclinalysis Files\1----Including dam fill\I98-2\I98-2 - GTILT\I98-2.gtl

Highland Valley Copper - Logan Lake, BC

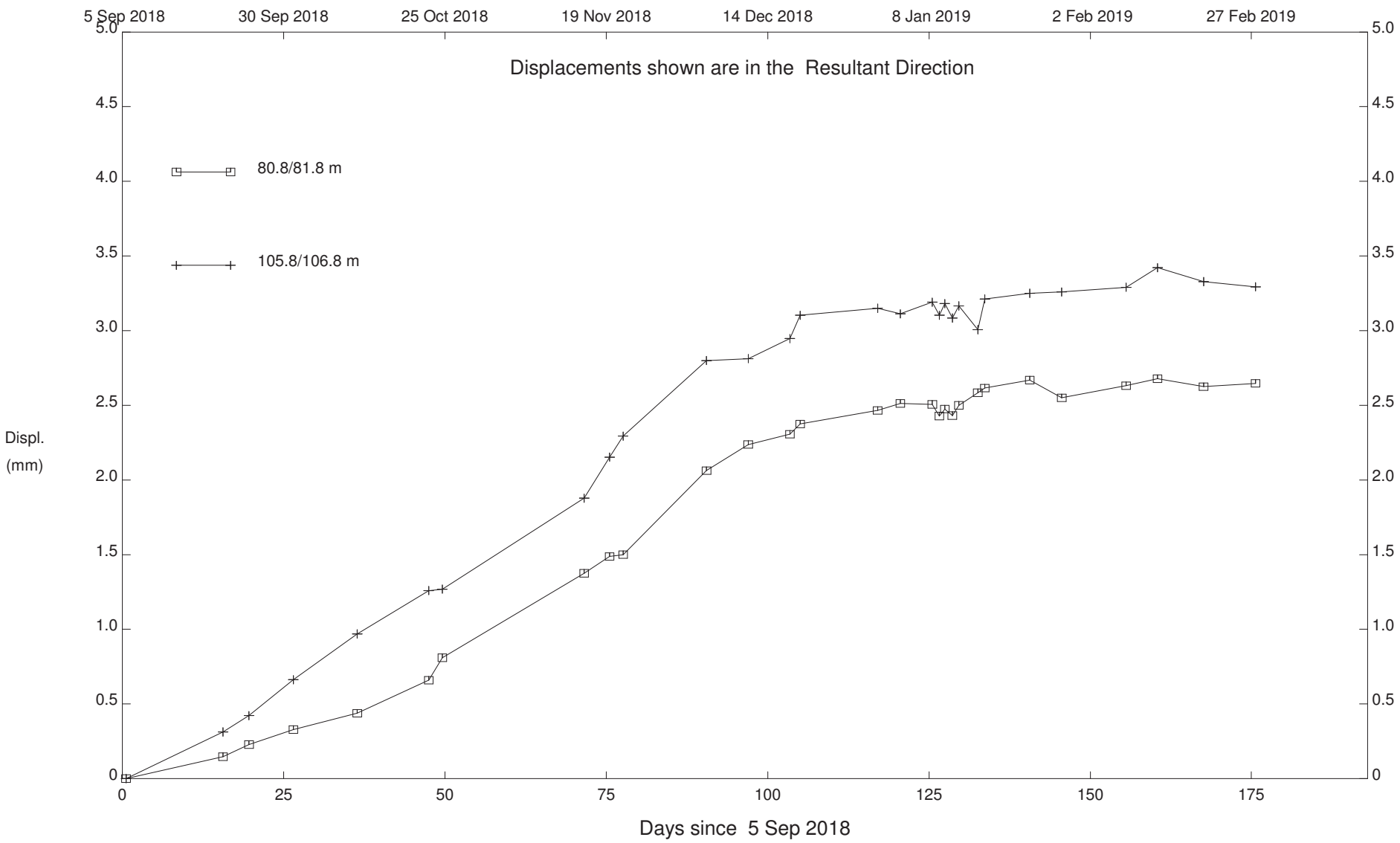


LL Dam - Dam fill excluded, Inclinometer I98-2

Sets marked * include zero shift and/or rotation corrections.

V:\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\L-L Dam\SI Monitoring\Inclinalysis Files\1----Including dam fill\I98-2\I98-2 - GTILT\I98-2.gtl

Highland Valley Copper - Logan Lake, BC



LL Dam - Dam fill excluded, Inclinometer I98-2

NORTH DAM

I98-03

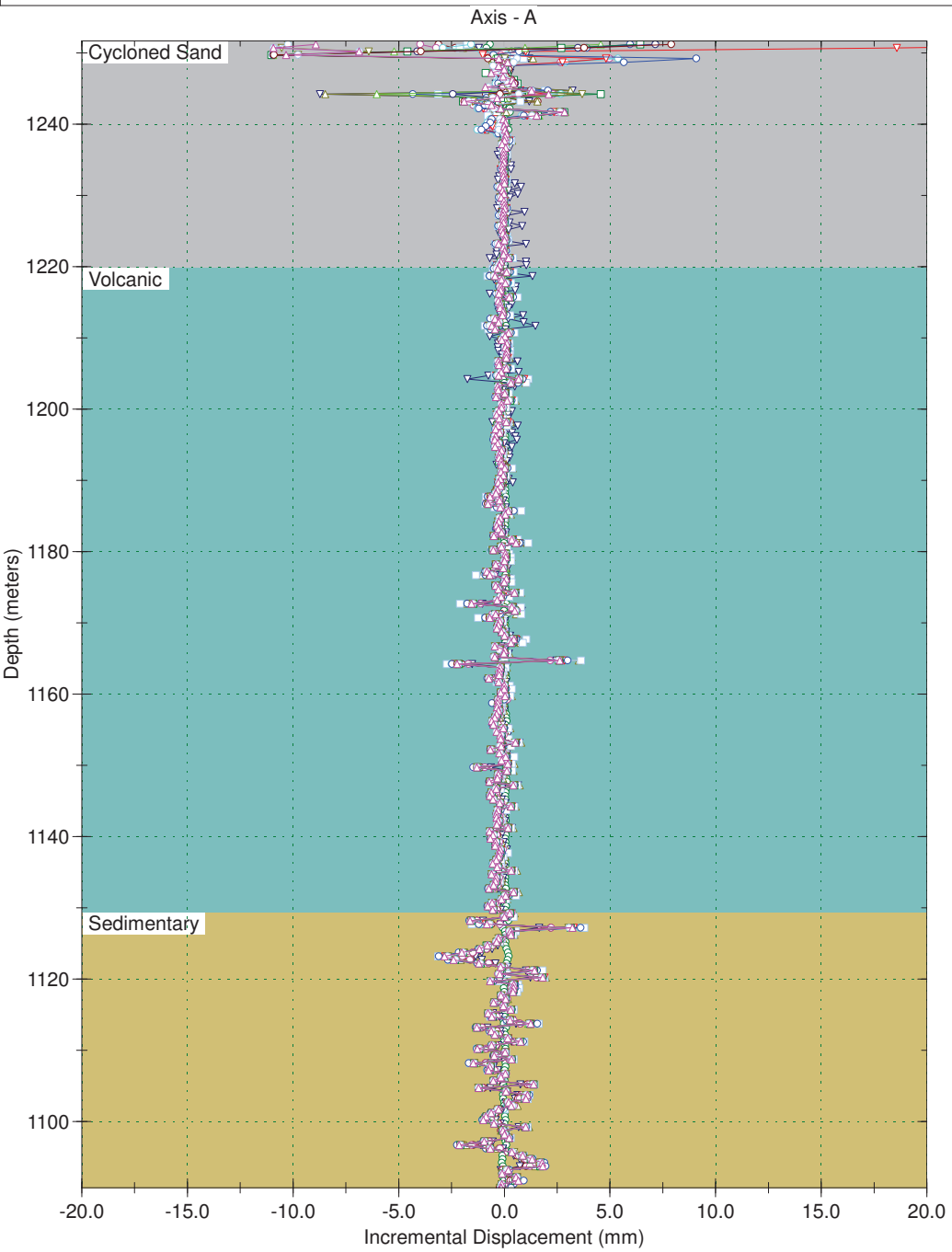
RST Instruments Ltd.

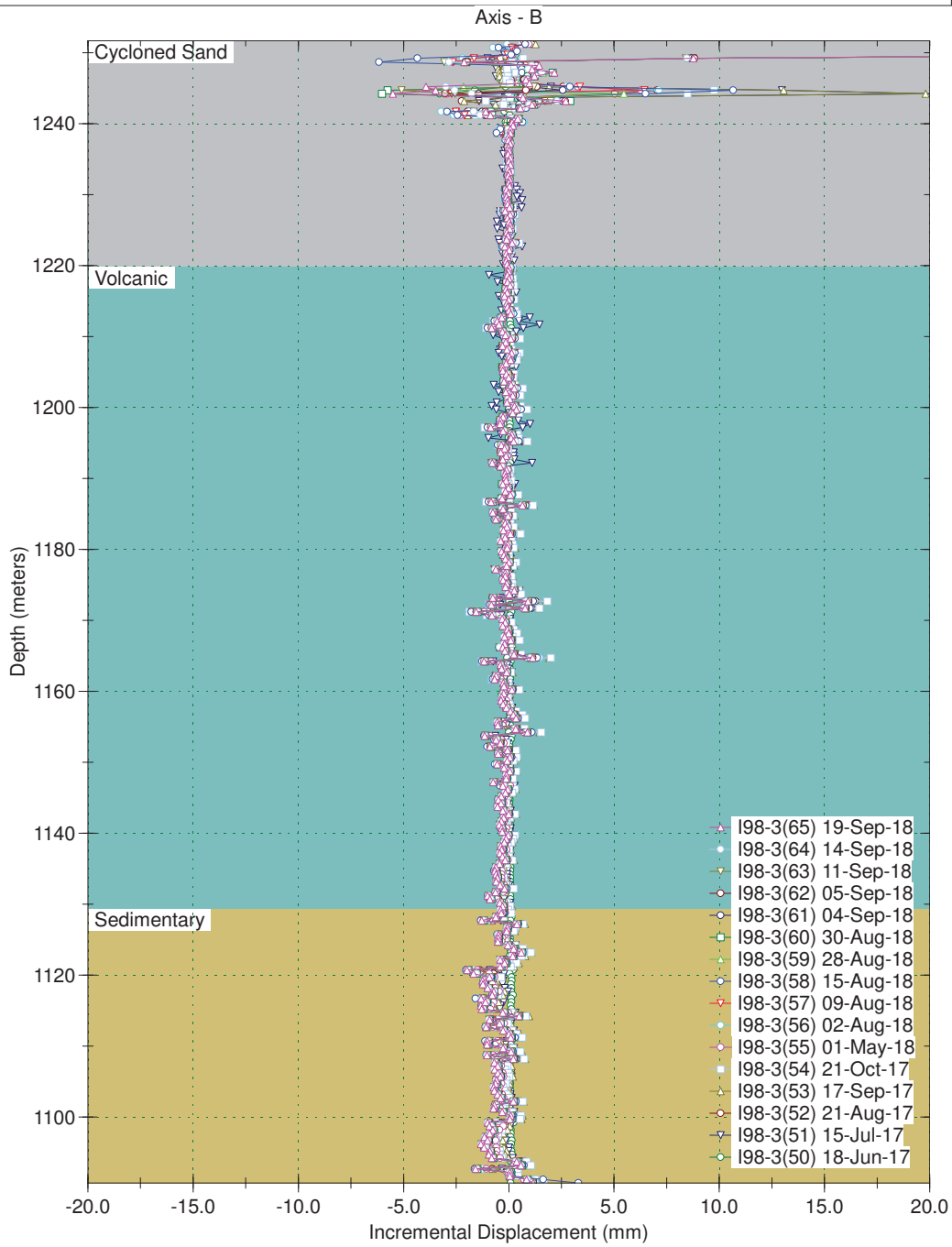
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I98-3
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1251.70 meters
Reading Depth : 161.0 meters
A+ Groove Azimuth :
Base Reading : 2017 Apr 01 03:59
Applied Azimuth : 0.0 degrees





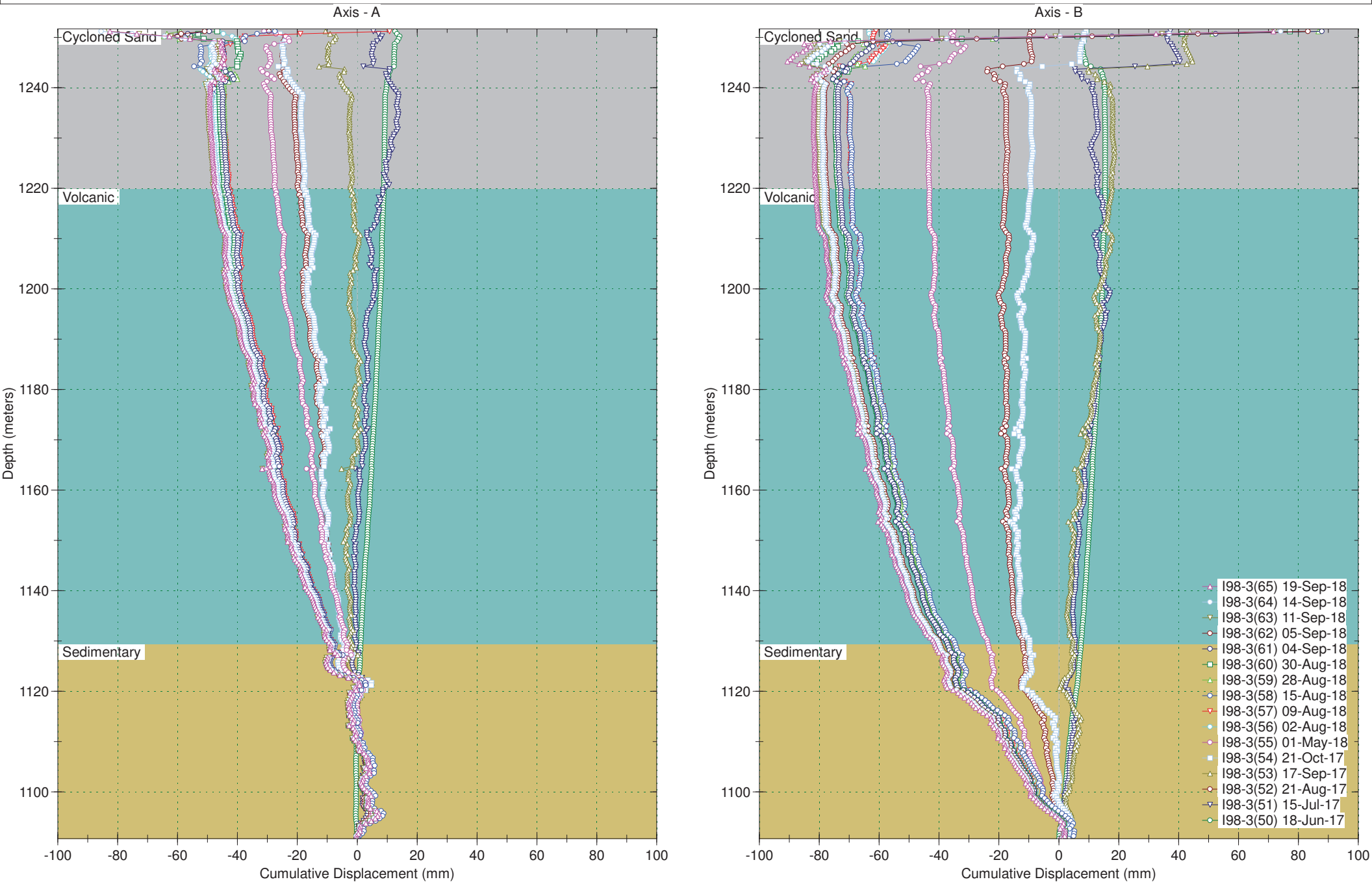
RST Instruments Ltd.

CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I98-3
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1251.70 meters
Reading Depth : 161.0 meters
A+ Groove Azimuth :
Base Reading : 2017 Apr 01 03:59
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

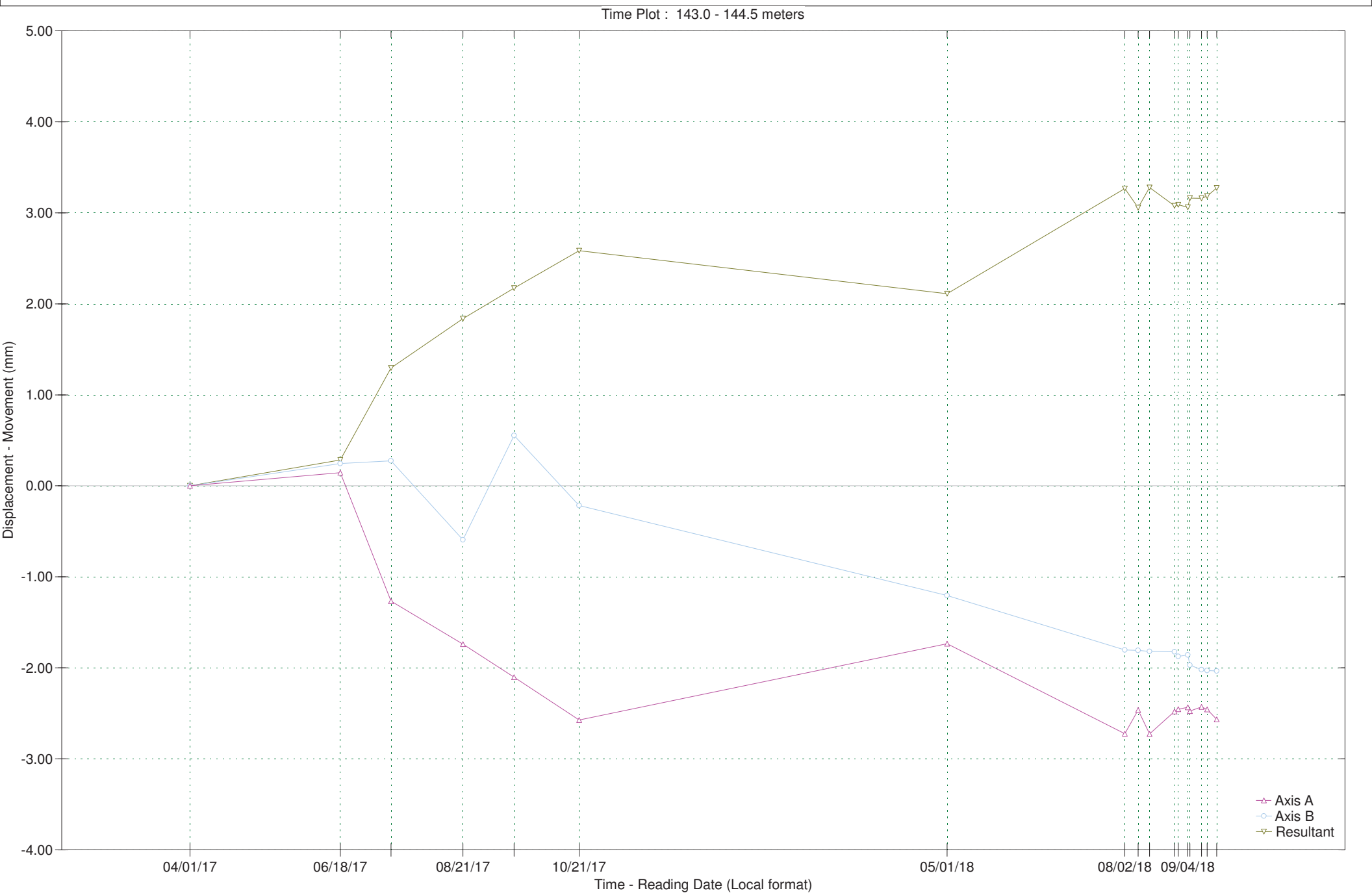
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I98-3
Location :
Northing :
Easting :
Collar :
Collar Elev : 1251.70 meters

Spiral Correction : N/A
Movement Depth : 143.0 - 144.5 meters
Reading Depth : 161.0 meters
A+ Groove Azimuth :
Latest Reading : 2018 Sep 19 11:34
Initial Reading : 2017 Apr 01 03:59
Applied Azimuth : 0.0 degrees



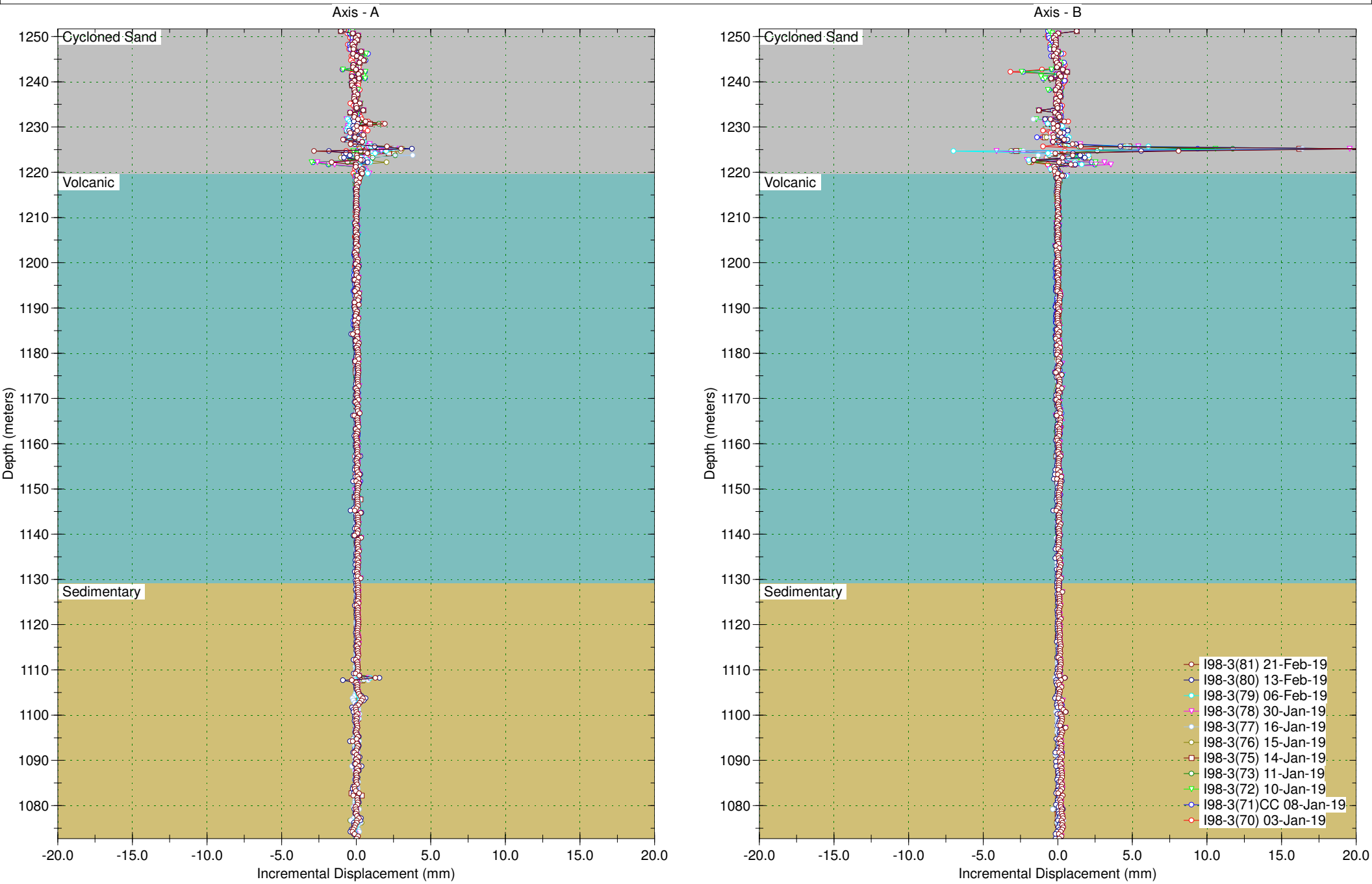
RST Instruments Ltd.

INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I98-3
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1251.70 meters
Reading Depth : 179.0 meters
A+ Groove Azimuth :
Base Reading : 2018 Dec 18 09:40
Applied Azimuth : 0.0 degrees



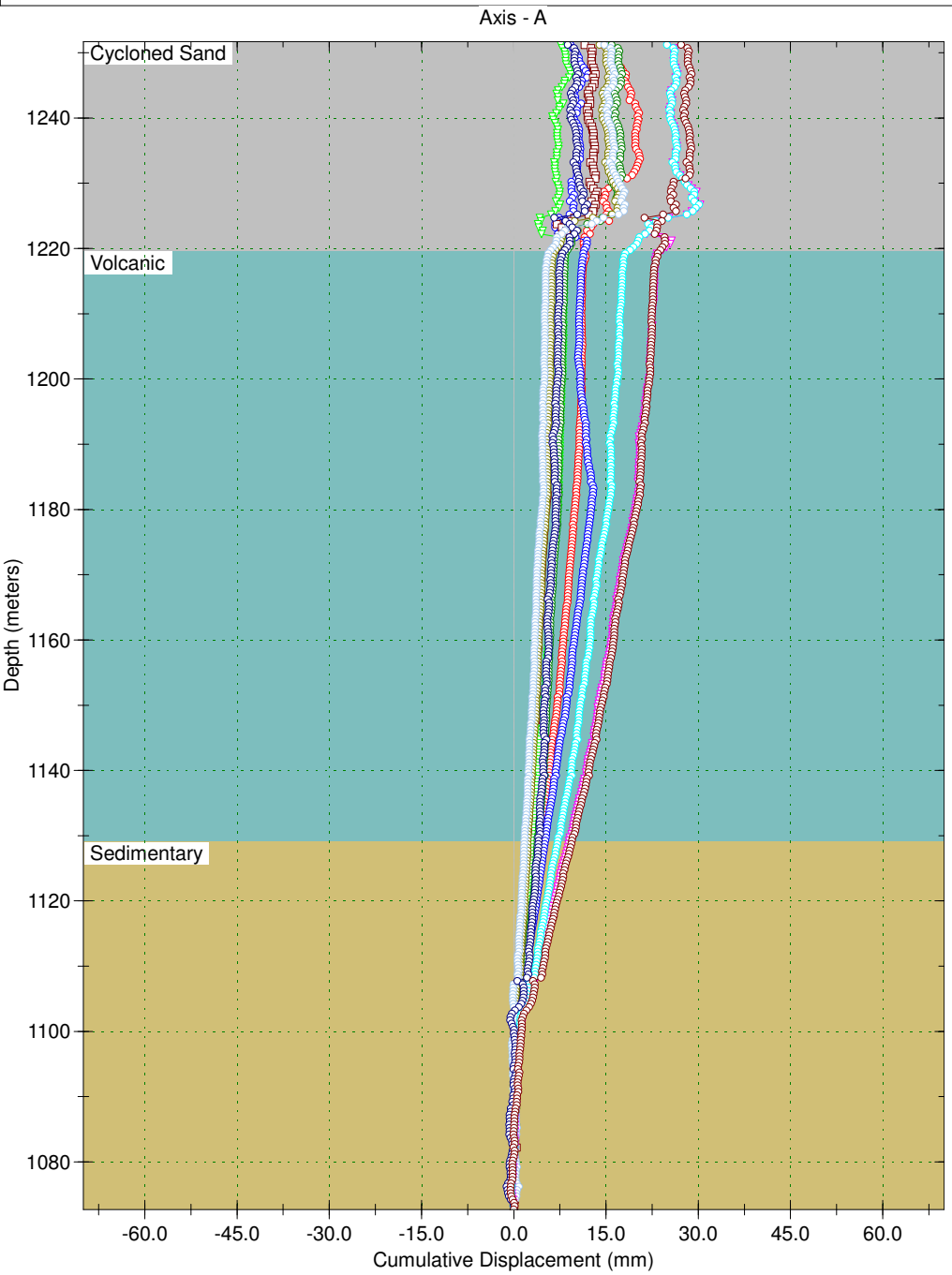
RST Instruments Ltd.

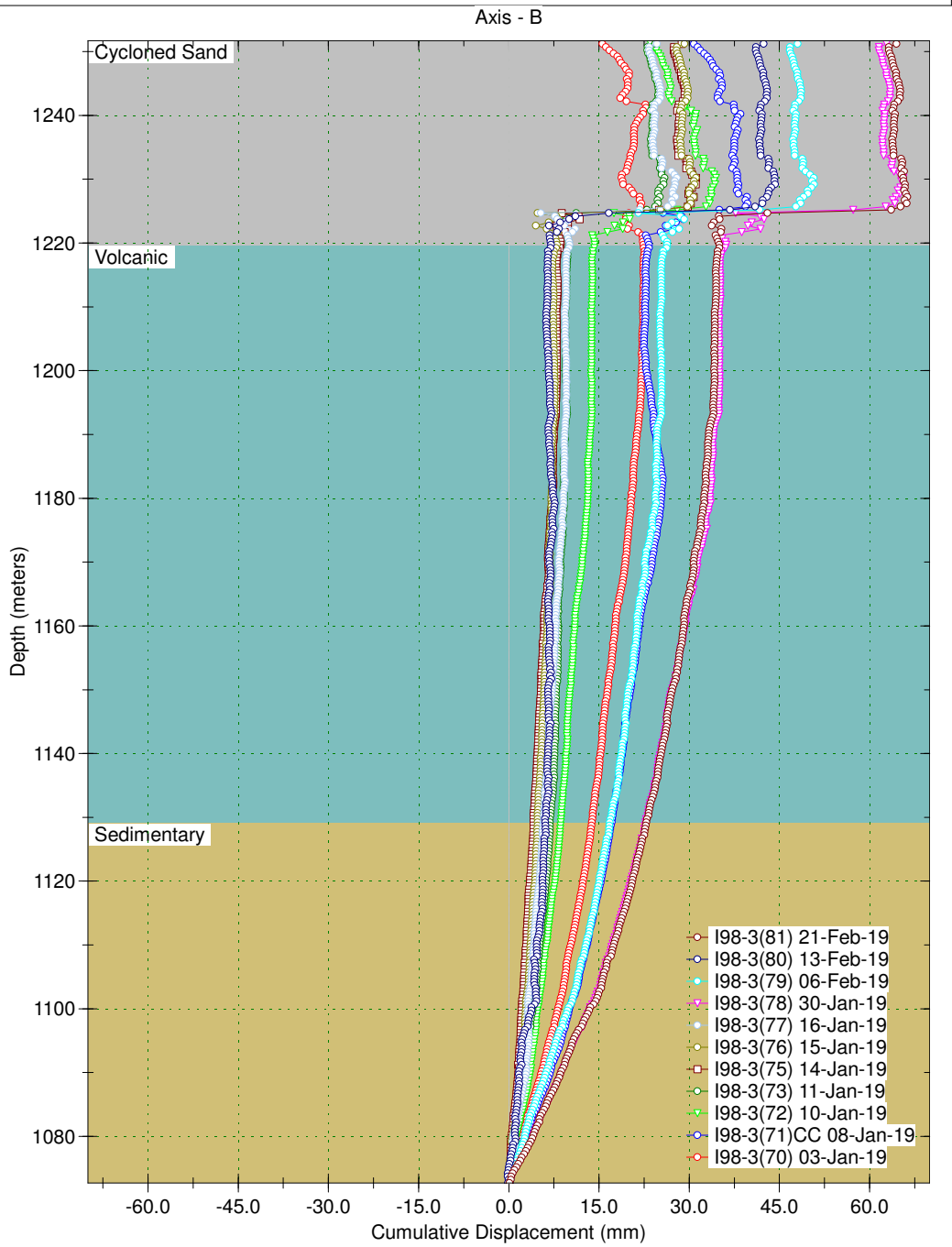
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I98-3
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1251.70 meters
Reading Depth : 179.0 meters
A+ Groove Azimuth :
Base Reading : 2018 Dec 18 09:40
Applied Azimuth : 0.0 degrees





RST Instruments Ltd.

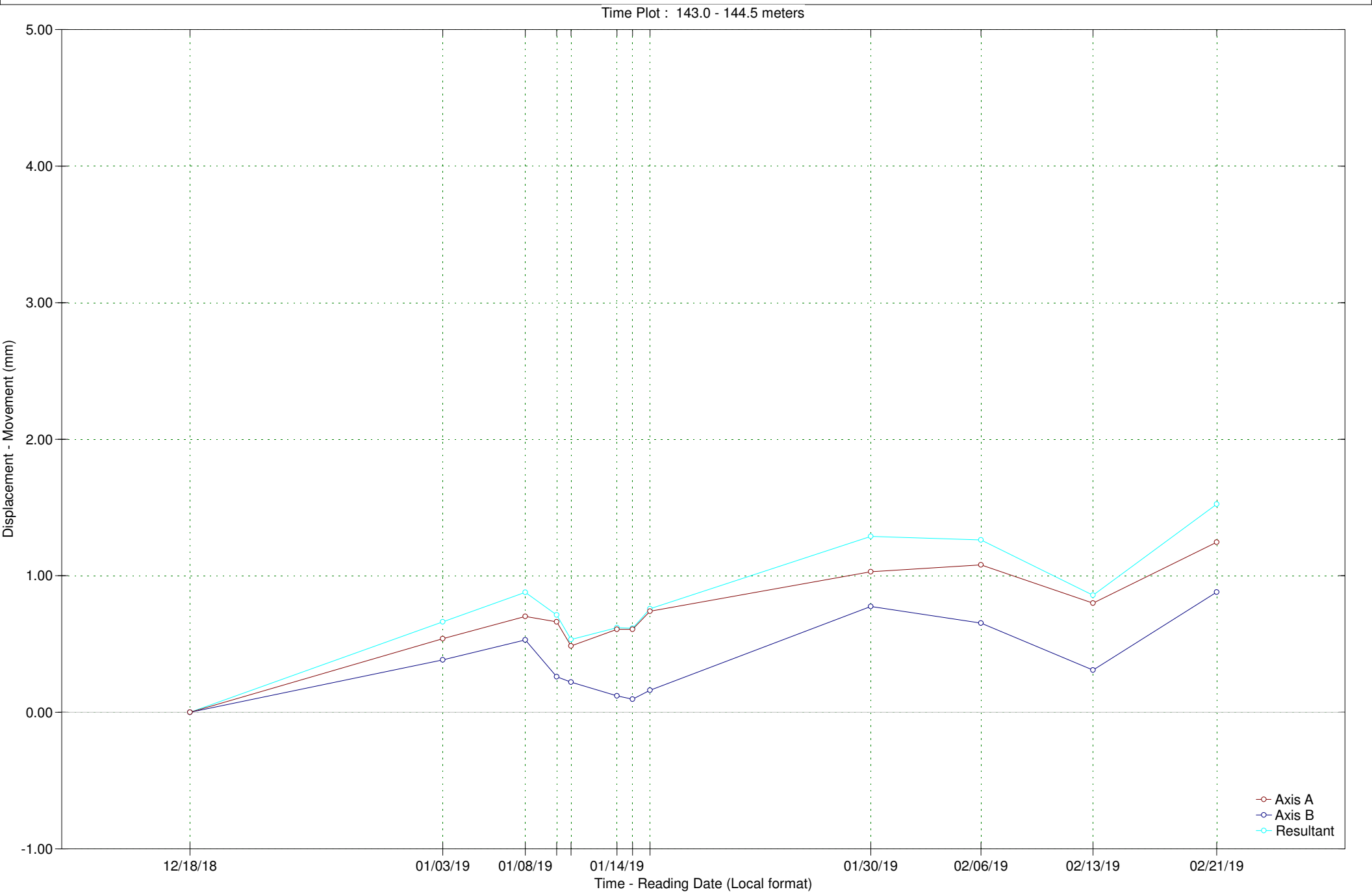
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I98-3
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1251.70 meters

Spiral Correction : N/A
Movement Depth : 143.0 - 144.5 meters
Reading Depth : 179.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 21 11:11
Initial Reading : 2018 Dec 18 09:40
Applied Azimuth : 0.0 degrees



NORTH DAM

I10-03

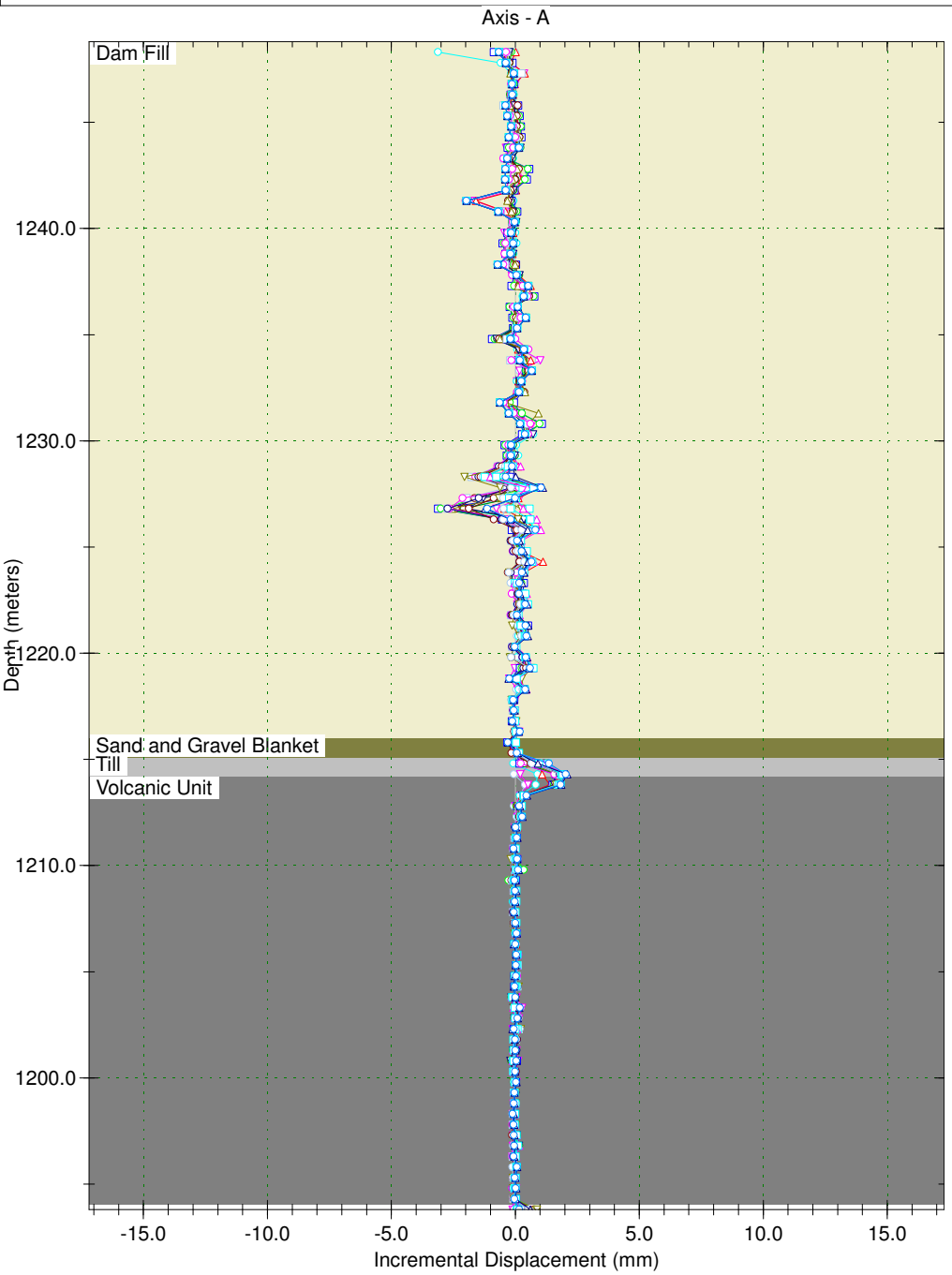
RST Instruments Ltd.

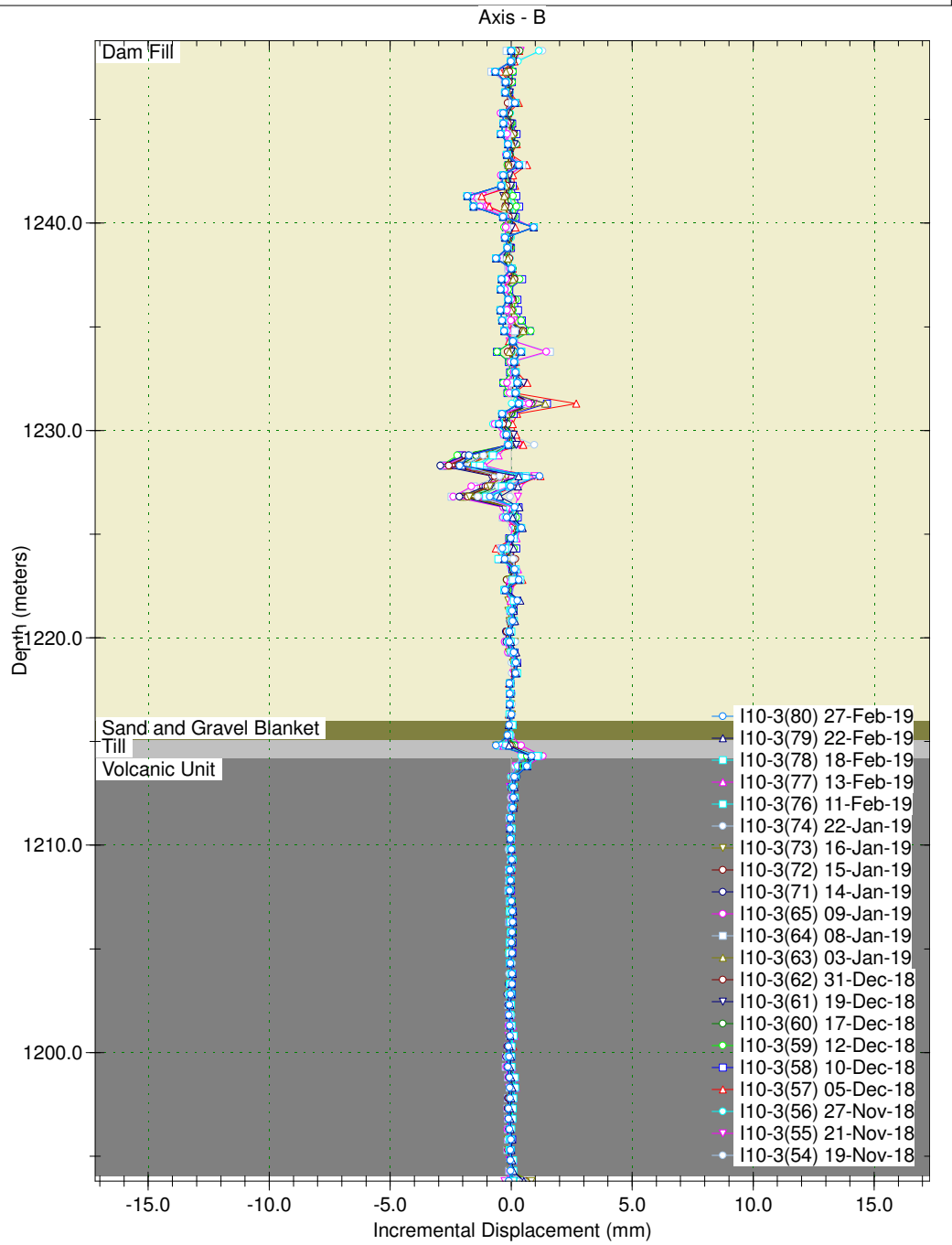
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I10-3
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1248.80 meters
Reading Depth : 55.0 meters
A+ Groove Azimuth :
Base Reading : 2018 Nov 15 11:51
Applied Azimuth : 0.0 degrees





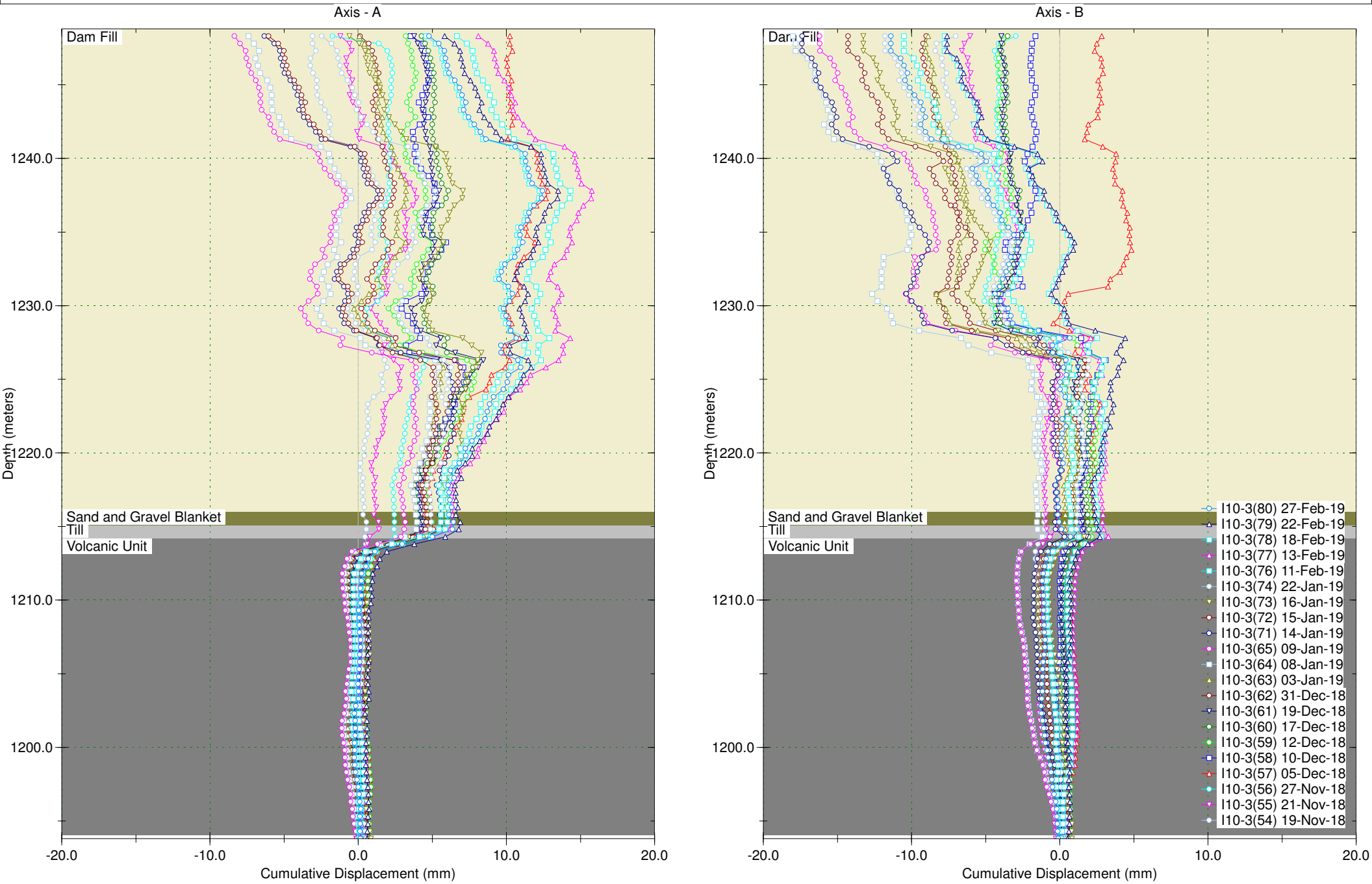
RST Instruments Ltd.

CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I10-3
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1248.80 meters
Reading Depth : 55.0 meters
A+ Groove Azimuth :
Base Reading : 2018 Nov 15 11:51
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

TIME PLOT

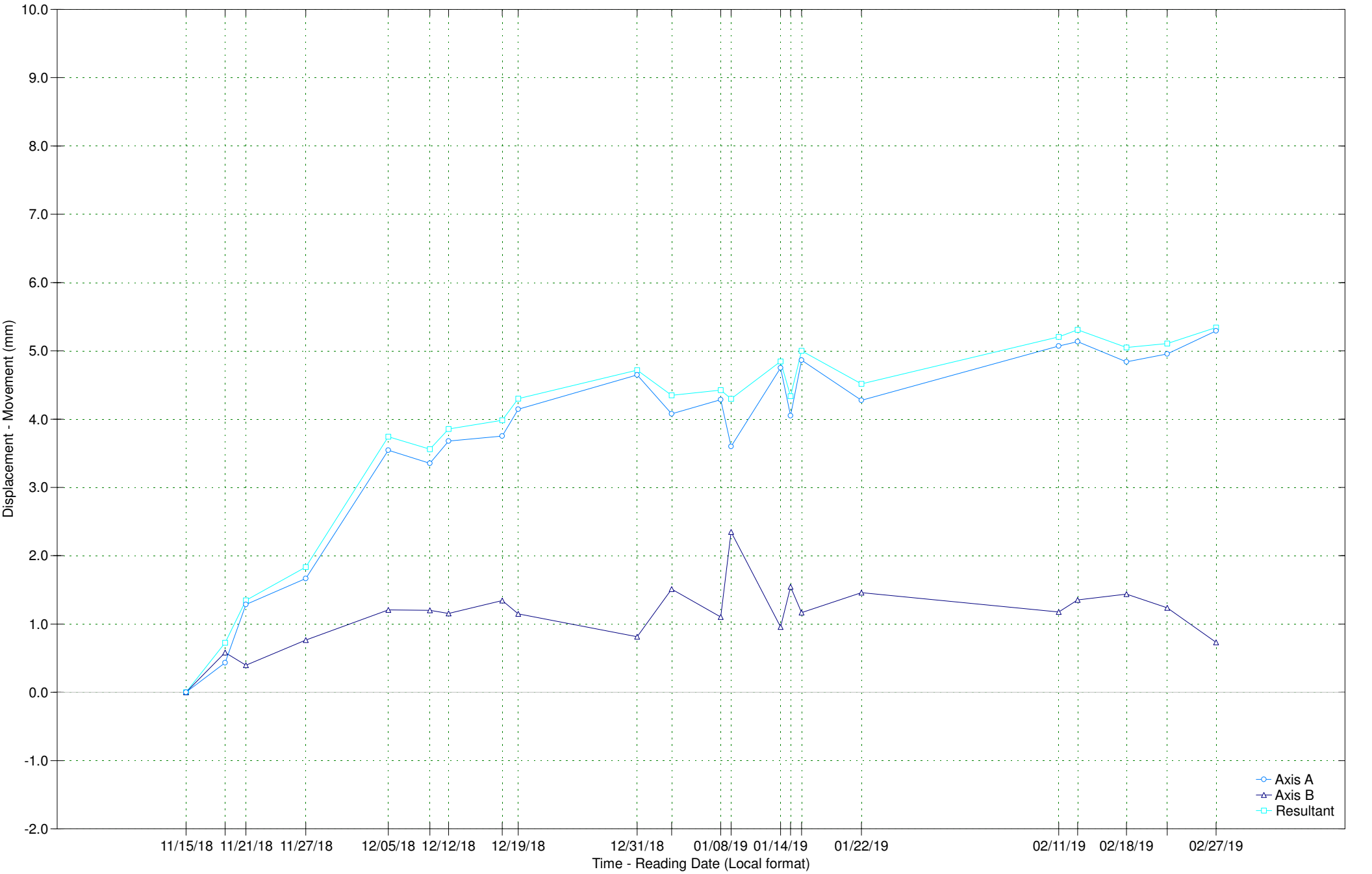
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I10-3
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1248.80 meters

Spiral Correction : N/A
Movement Depth : 33.5 - 35.0 meters
Reading Depth : 55.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 27 10:25
Initial Reading : 2018 Nov 15 11:51
Applied Azimuth : 0.0 degrees

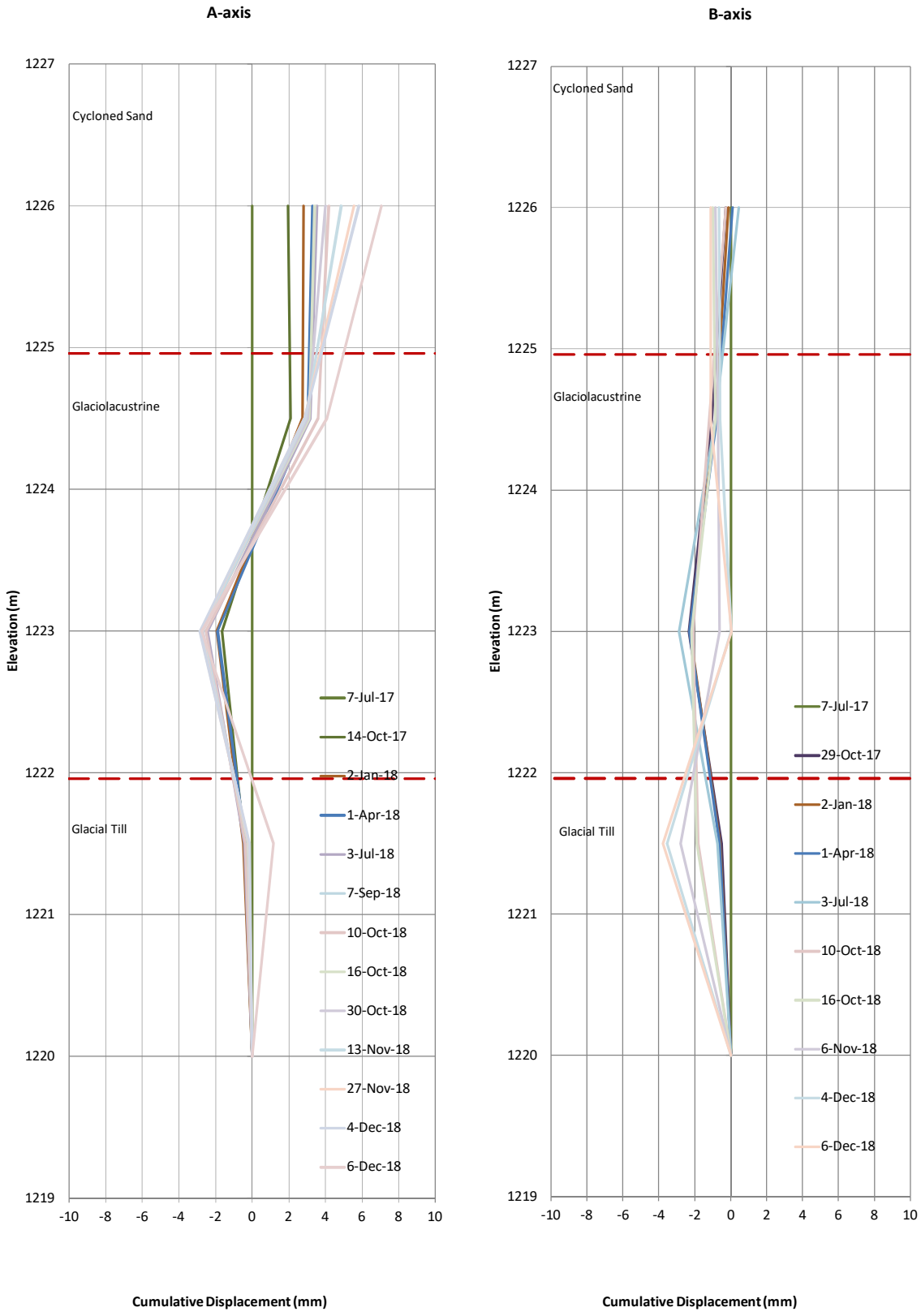
Time Plot : 33.5 - 35.0 meters

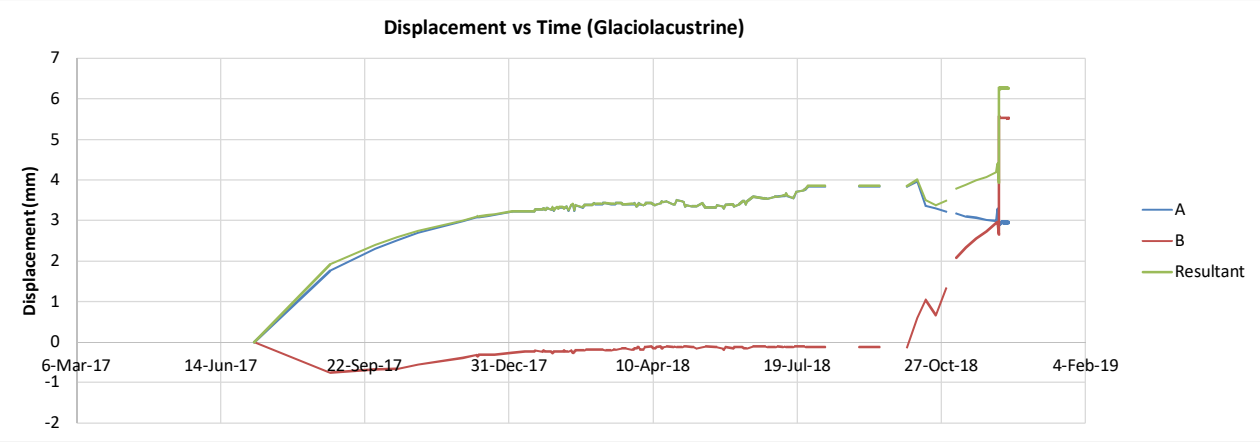


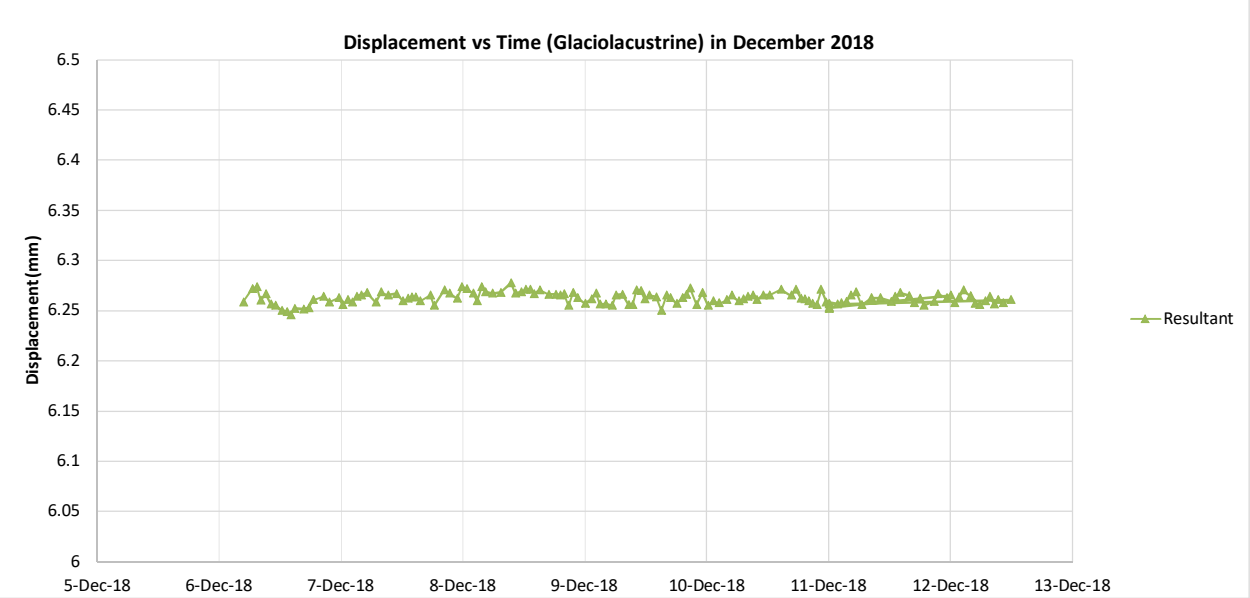
NORTH DAM

I16-05

I16-5 (IPI)


A-axis
B-axis
Cycloned Sand
Glaciolacustrine
Glacial Till
Elevation (m)
1227
1226
1225
1224
1223
1222
1221
1220
1219
-10
-8
-6
-4
-2
0
2
4
6
8
10
Cumulative Displacement (mm)
7-Jul-17
14-Oct-17
2-Jan-18
1-Apr-18
3-Jul-18
7-Sep-18
10-Oct-18
16-Oct-18
30-Oct-18
13-Nov-18
27-Nov-18
4-Dec-18
6-Dec-18
29-Oct-17
6-Nov-18


Displacement vs Time (Glaciolacustrine)
Displacement (mm)
7
6
5
4
3
2
1
0
-1
-2
6-Mar-17
14-Jun-17
22-Sep-17
31-Dec-17
10-Apr-18
19-Jul-18
27-Oct-18
4-Feb-19
A
B
Resultant


Displacement vs Time (Glaciolacustrine) in December 2018
Displacement (mm)
6.5
6.45
6.4
6.35
6.3
6.25
6.2
6.15
6.1
6.05
6
5-Dec-18
6-Dec-18
7-Dec-18
8-Dec-18
9-Dec-18
10-Dec-18
11-Dec-18
12-Dec-18
13-Dec-18
Resultant

NORTH DAM

I19-01

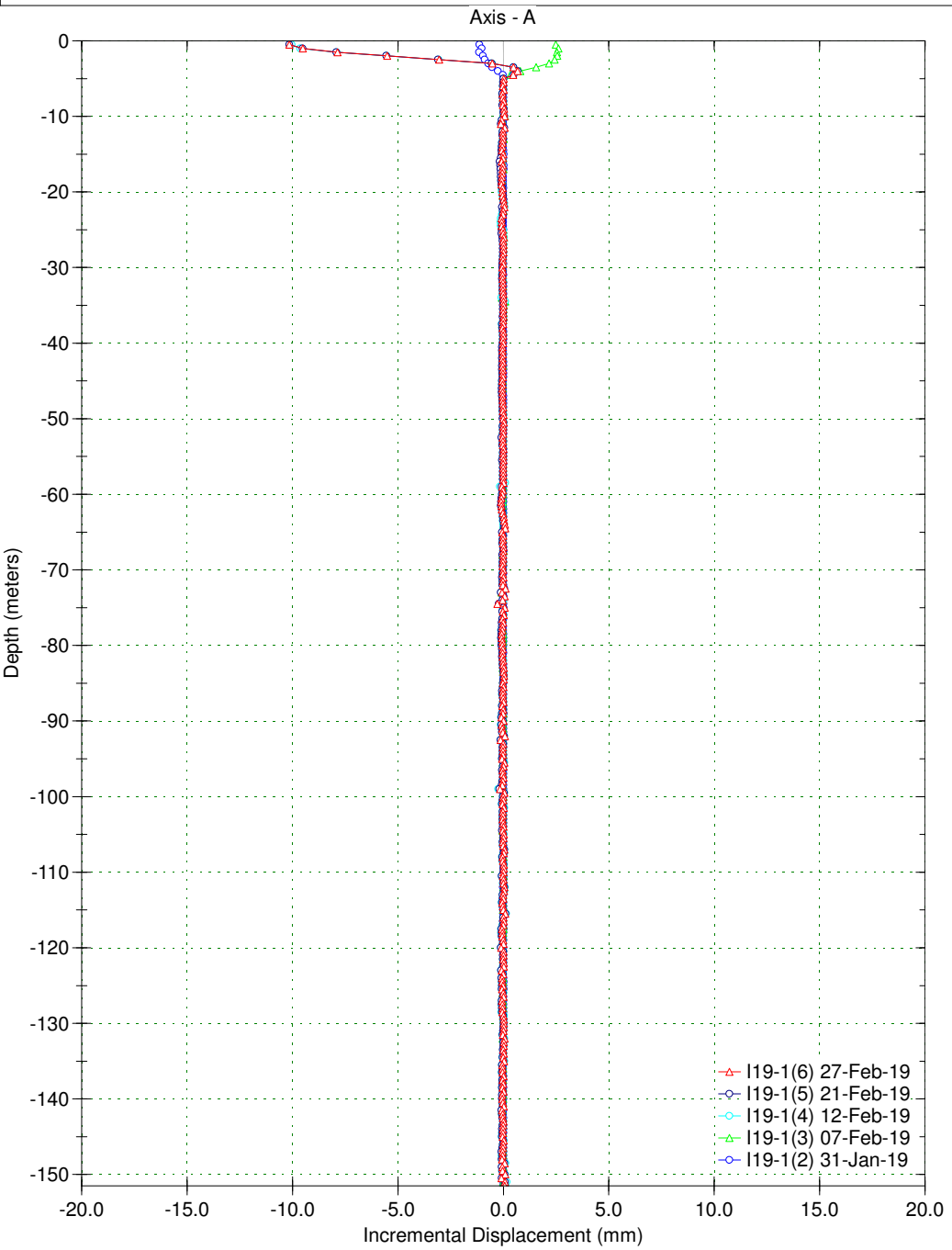
RST Instruments Ltd.

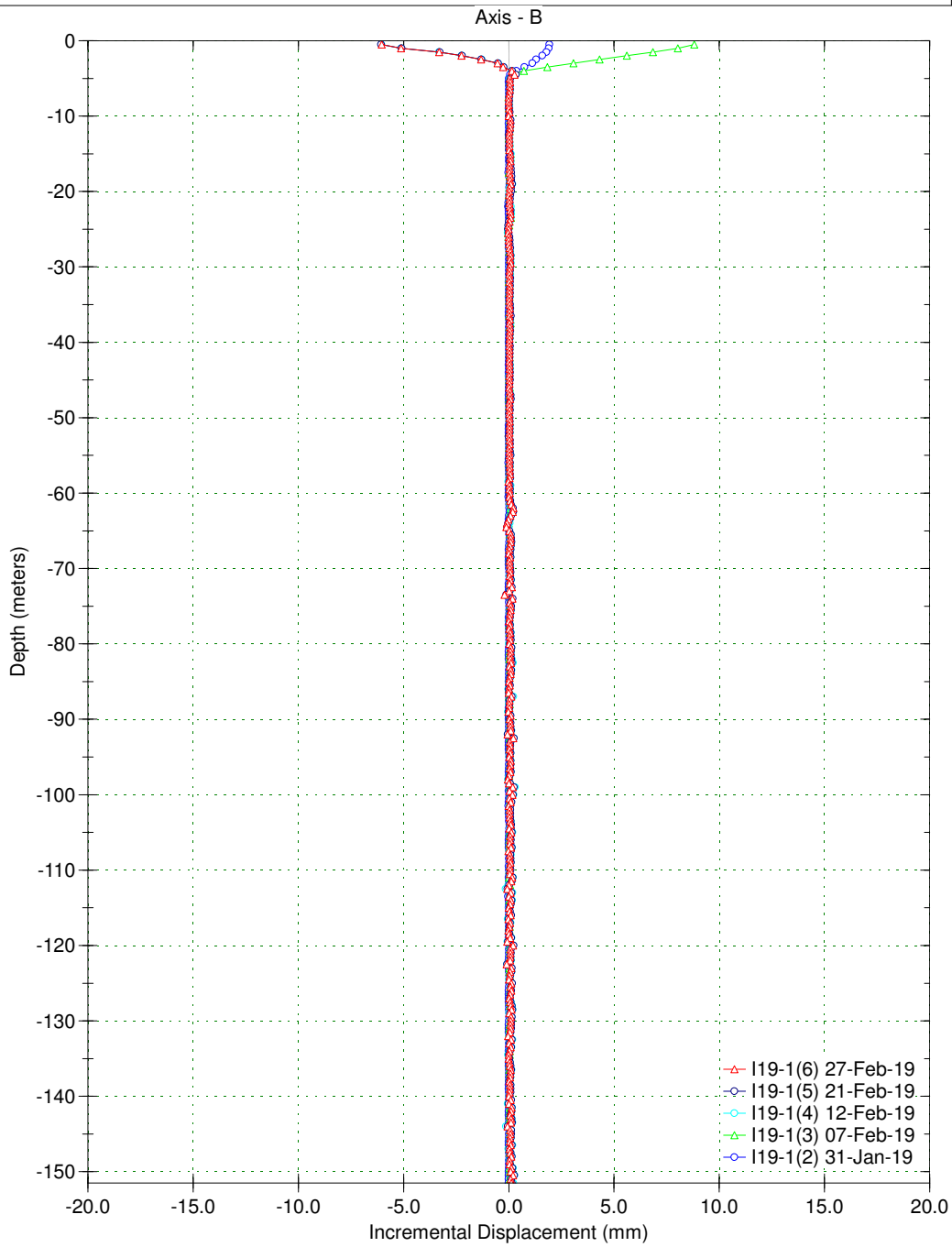
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I19-1
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 0.00 meters
Reading Depth : 151.5 meters
A+ Groove Azimuth :
Base Reading : 2019 Jan 31 12:01
Applied Azimuth : 0.0 degrees





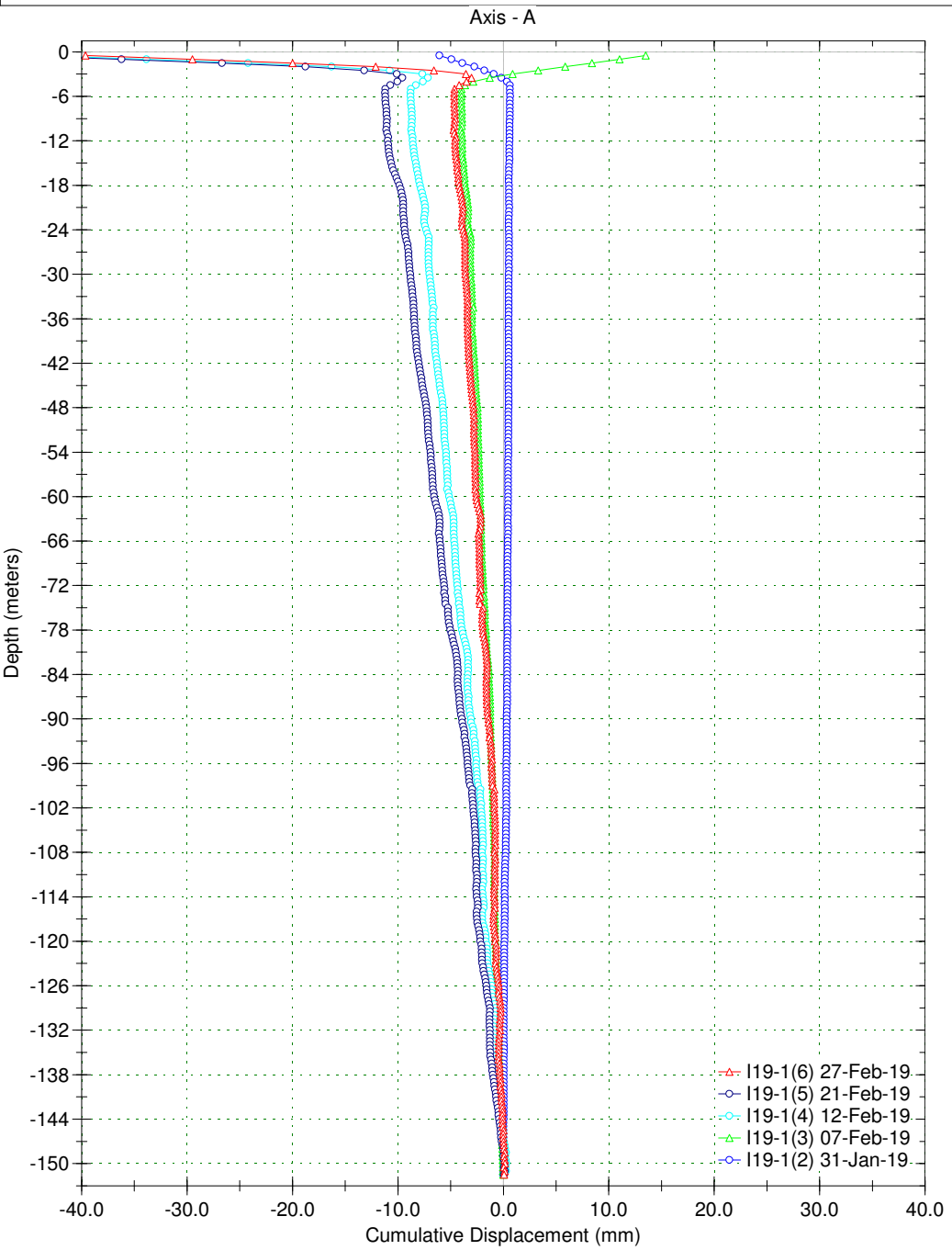
RST Instruments Ltd.

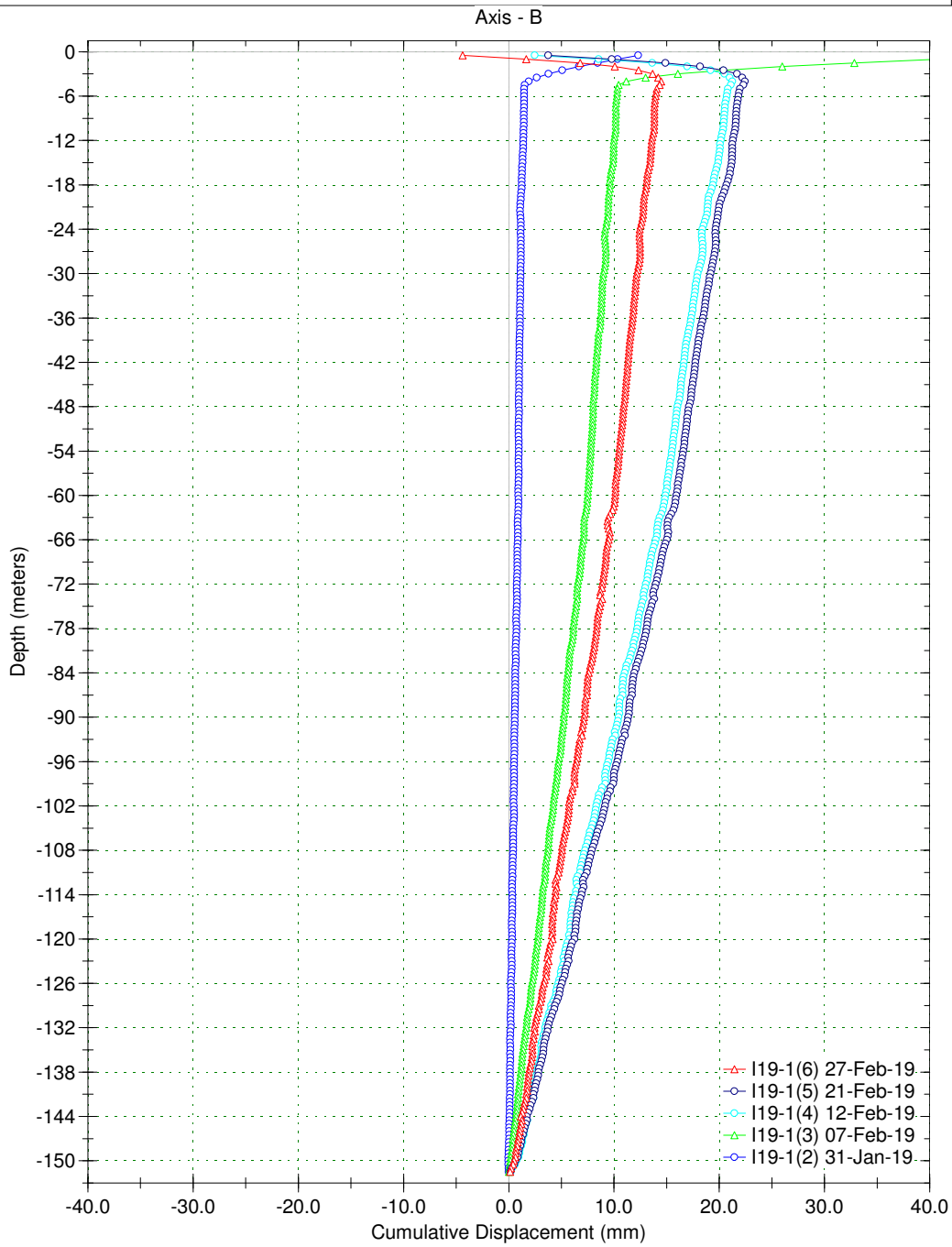
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I19-1
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 0.00 meters
Reading Depth : 151.5 meters
A+ Groove Azimuth :
Base Reading : 2019 Jan 31 12:01
Applied Azimuth : 0.0 degrees





RST Instruments Ltd.

TIME PLOT

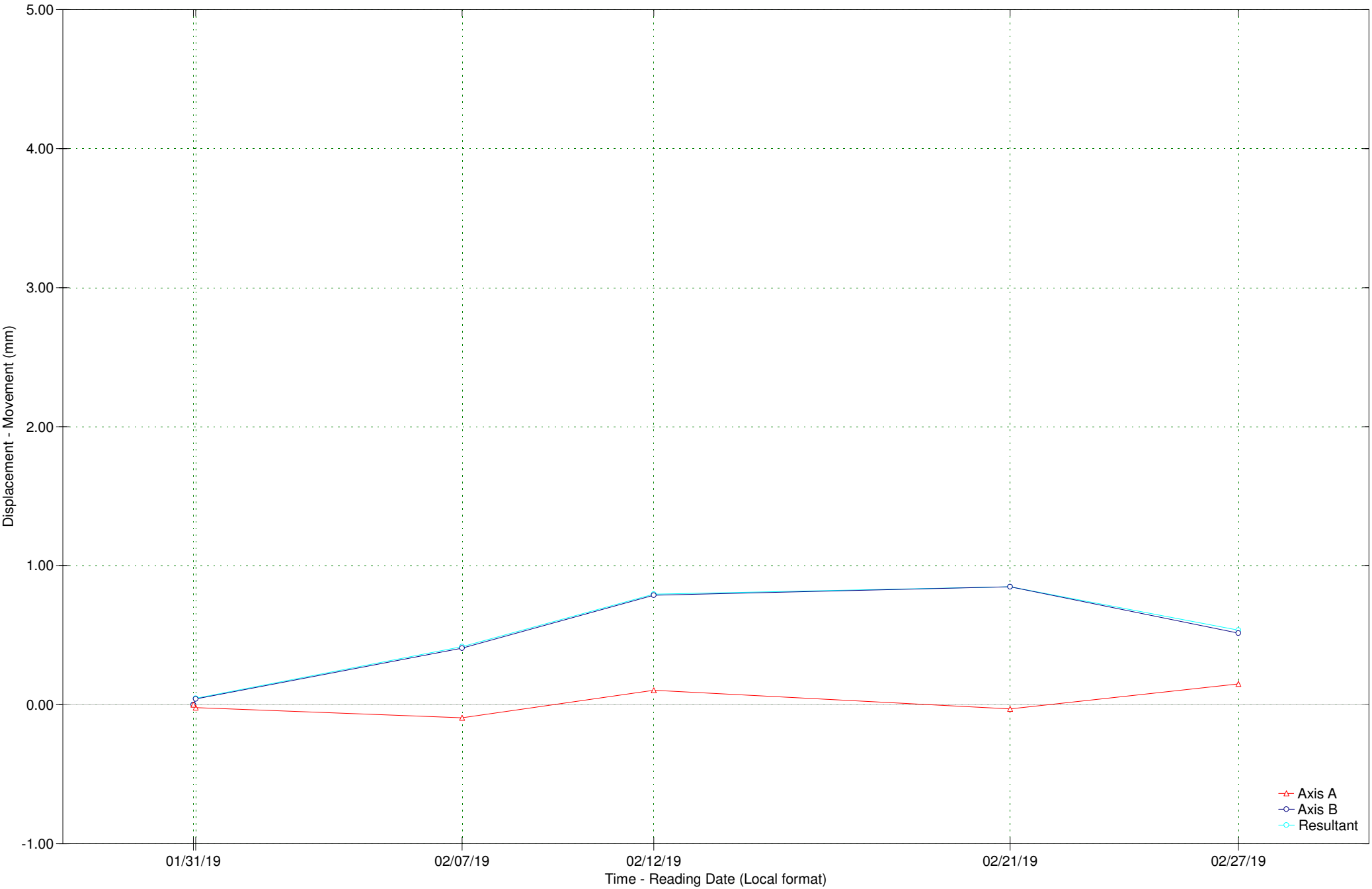
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I19-1
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 0.00 meters

Spiral Correction : N/A
Movement Depth : 130.0 - 134.0 meters
Reading Depth : 151.5 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 27 13:37
Initial Reading : 2019 Jan 31 12:01
Applied Azimuth : 0.0 degrees

Time Plot : 130.0 - 134.0 meters



RST Instruments Ltd.

TIME PLOT

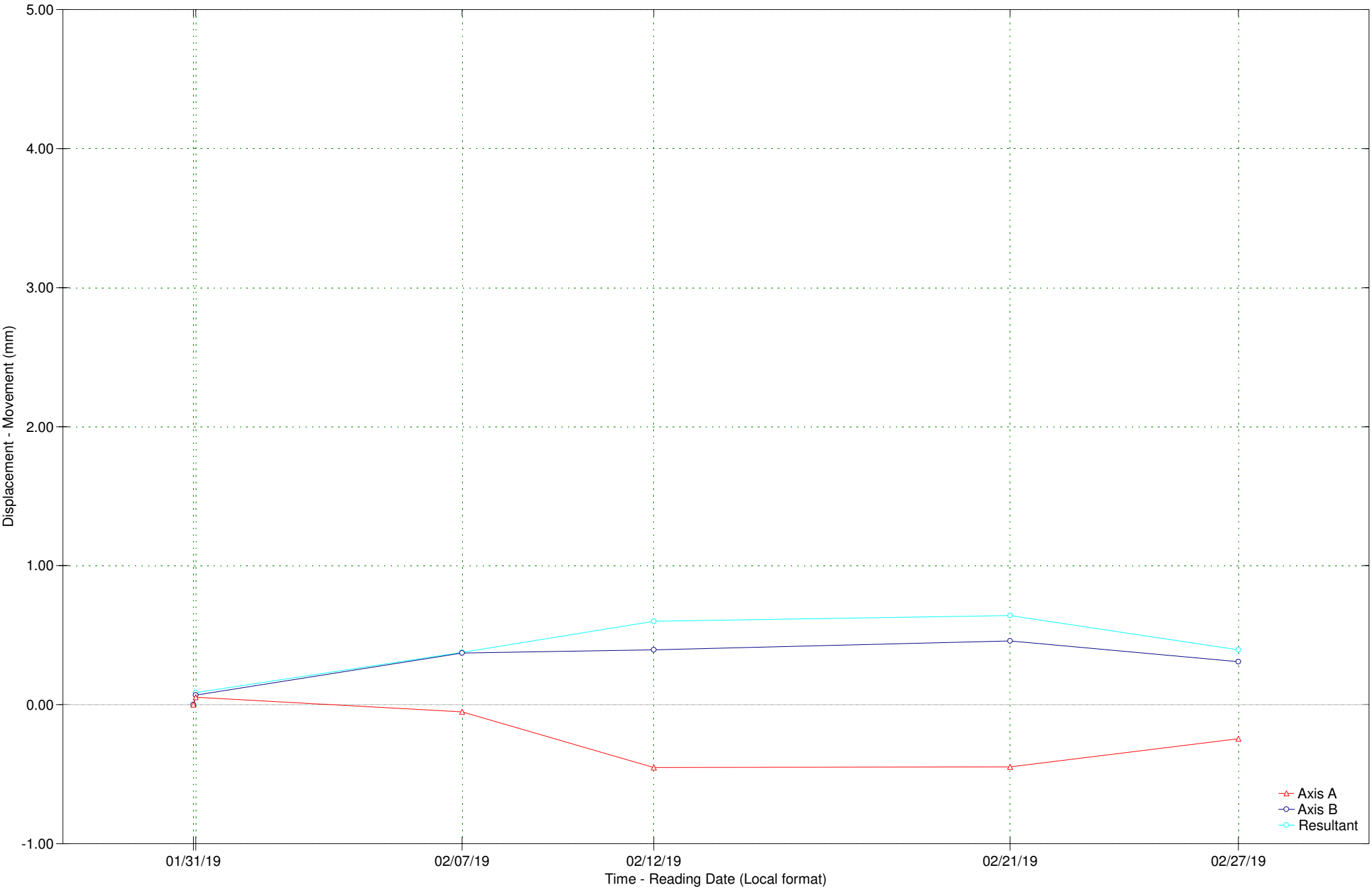
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I19-1
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 0.00 meters

Spiral Correction : N/A
Movement Depth : 88.0 - 92.0 meters
Reading Depth : 151.5 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 27 13:37
Initial Reading : 2019 Jan 31 12:01
Applied Azimuth : 0.0 degrees

Time Plot : 88.0 - 92.0 meters



RST Instruments Ltd.

TIME PLOT

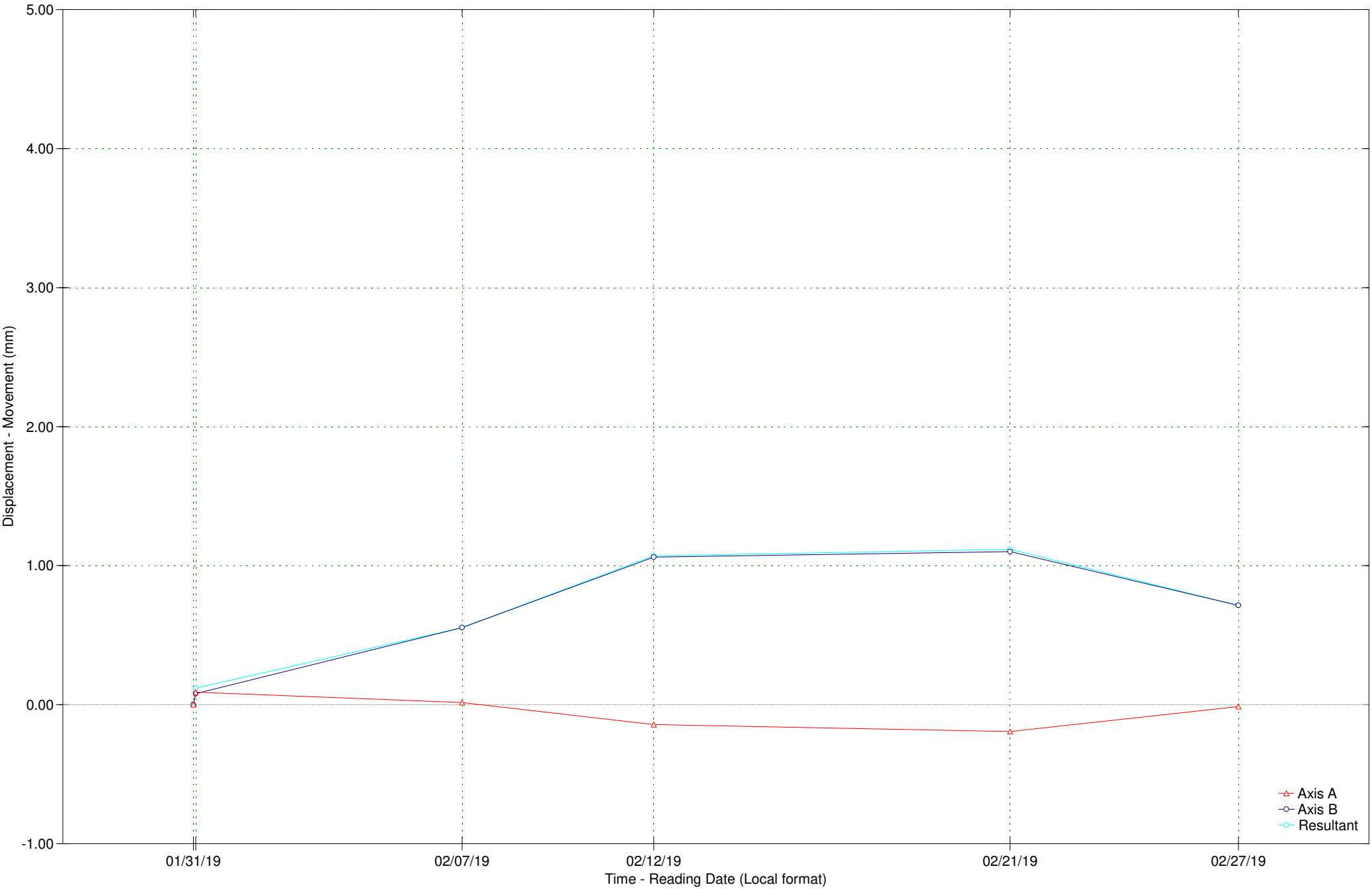
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I19-1
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 0.00 meters

Spiral Correction : N/A
Movement Depth : 108.0 - 114.0 meters
Reading Depth : 151.5 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 27 13:37
Initial Reading : 2019 Jan 31 12:01
Applied Azimuth : 0.0 degrees

Time Plot : 108.0 - 114.0 meters



NORTH DAM

I19-02

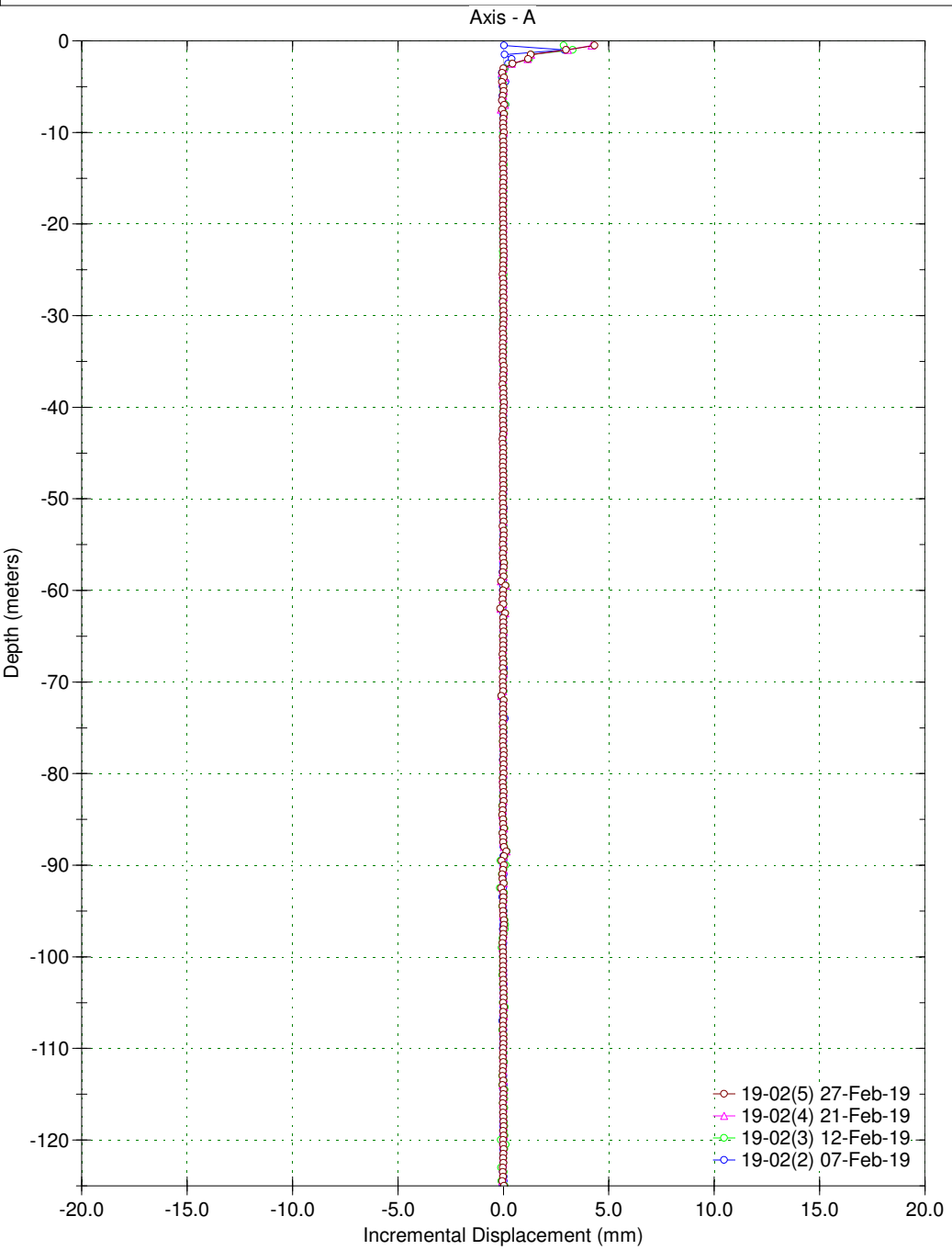
RST Instruments Ltd.

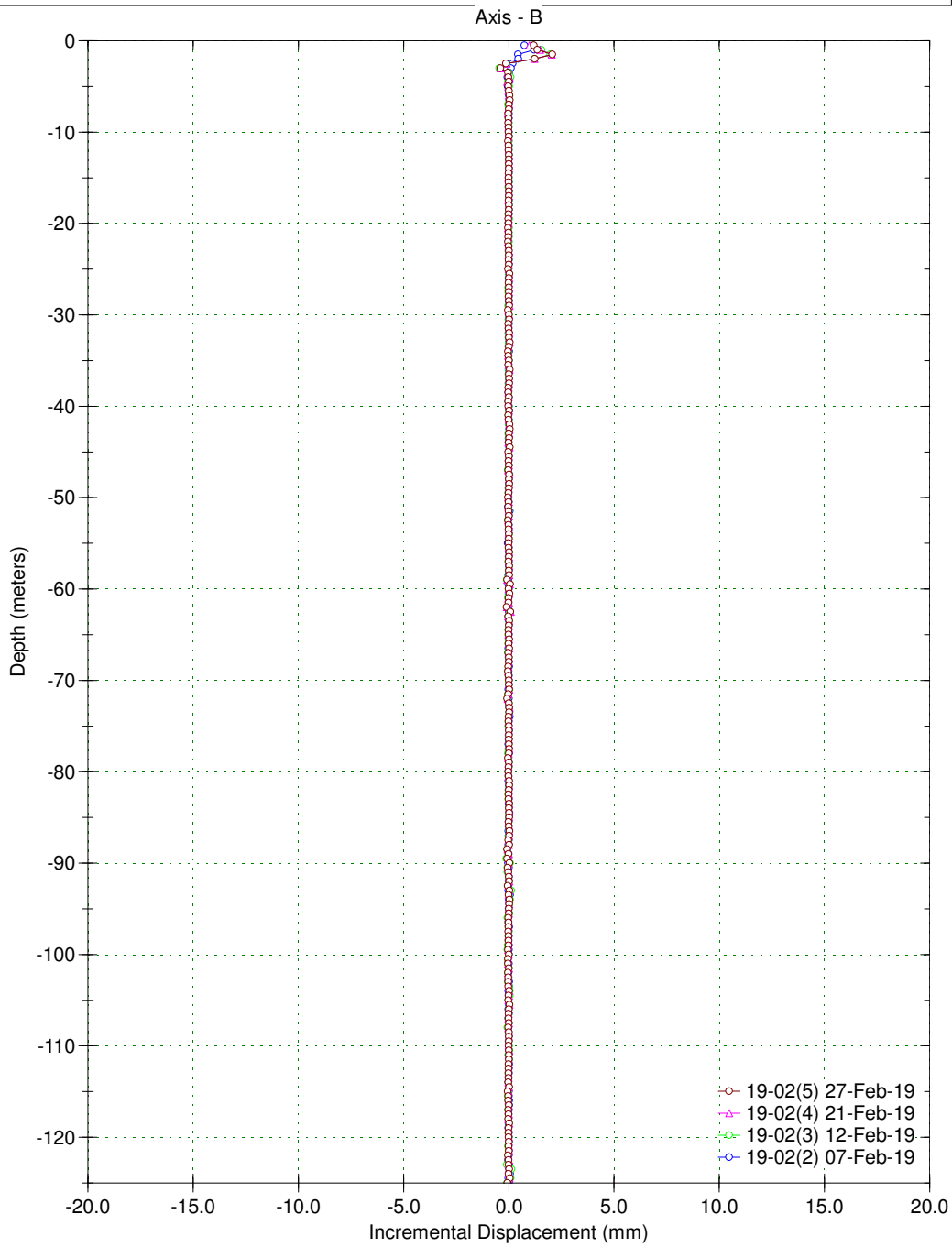
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I19-2
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 0.00 meters
Reading Depth : 125.0 meters
A+ Groove Azimuth :
Base Reading : 2019 Feb 07 10:13
Applied Azimuth : 0.0 degrees





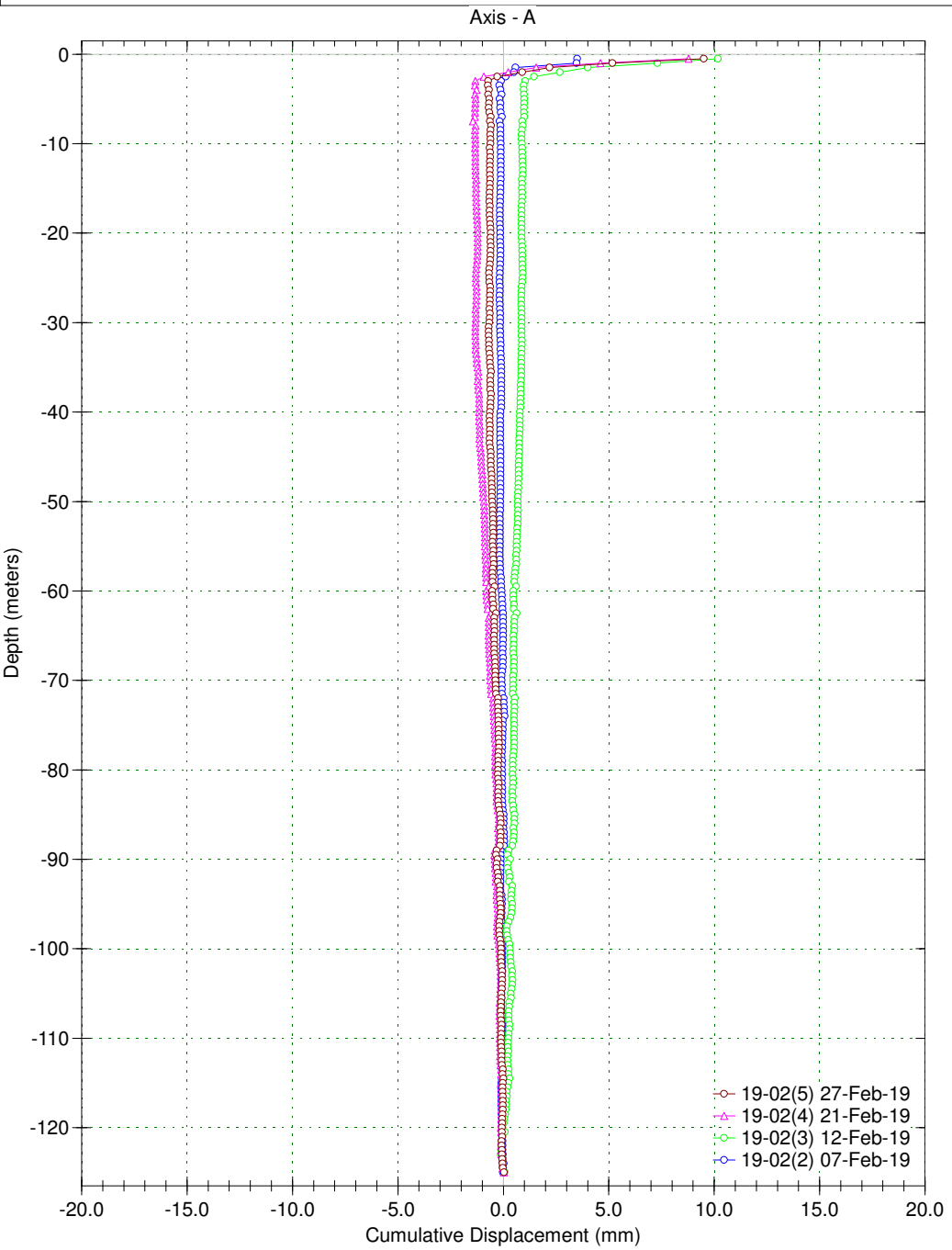
RST Instruments Ltd.

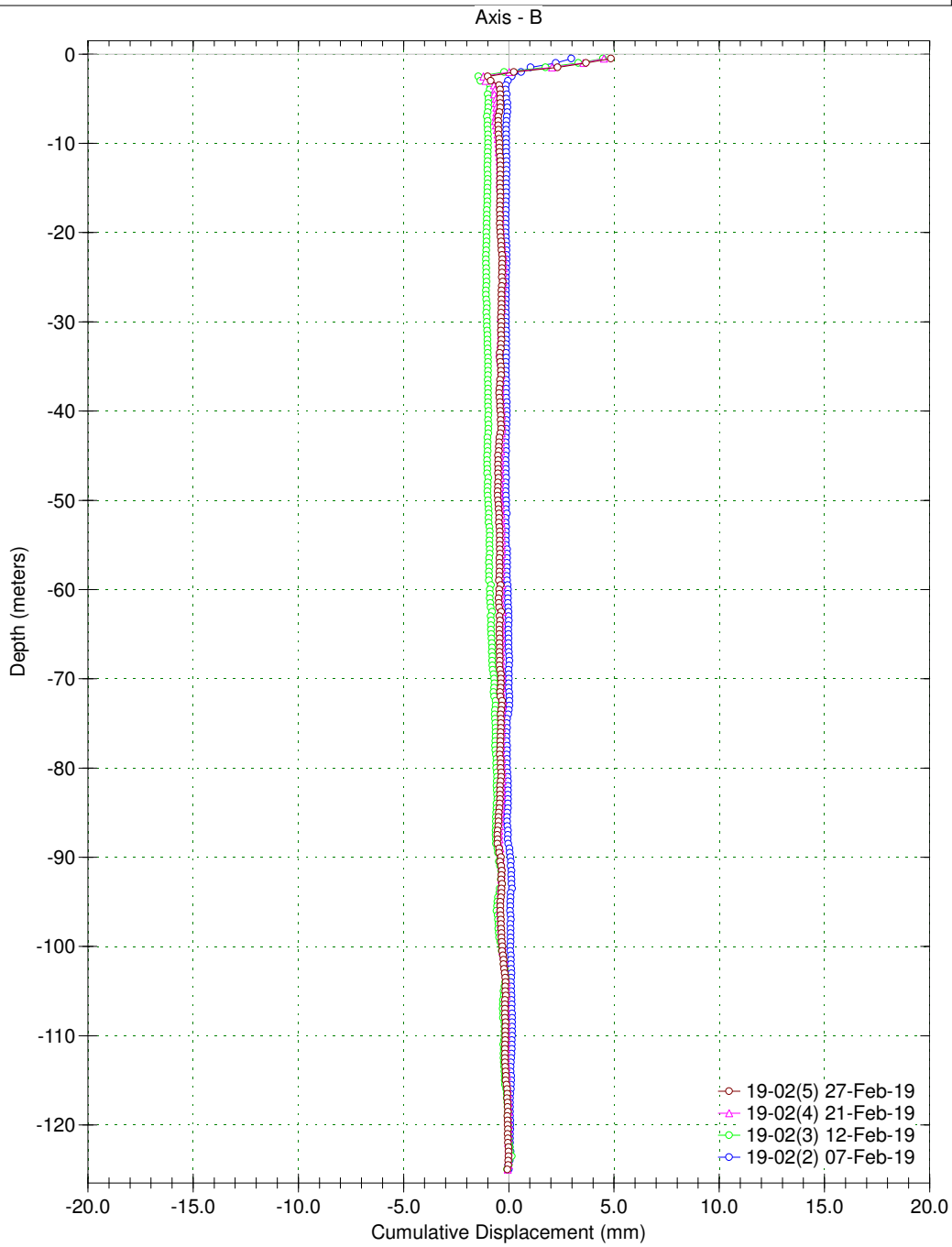
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I19-2
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 0.00 meters
Reading Depth : 125.0 meters
A+ Groove Azimuth :
Base Reading : 2019 Feb 07 10:13
Applied Azimuth : 0.0 degrees





NORTH BUTTRESS BERM

I10-12

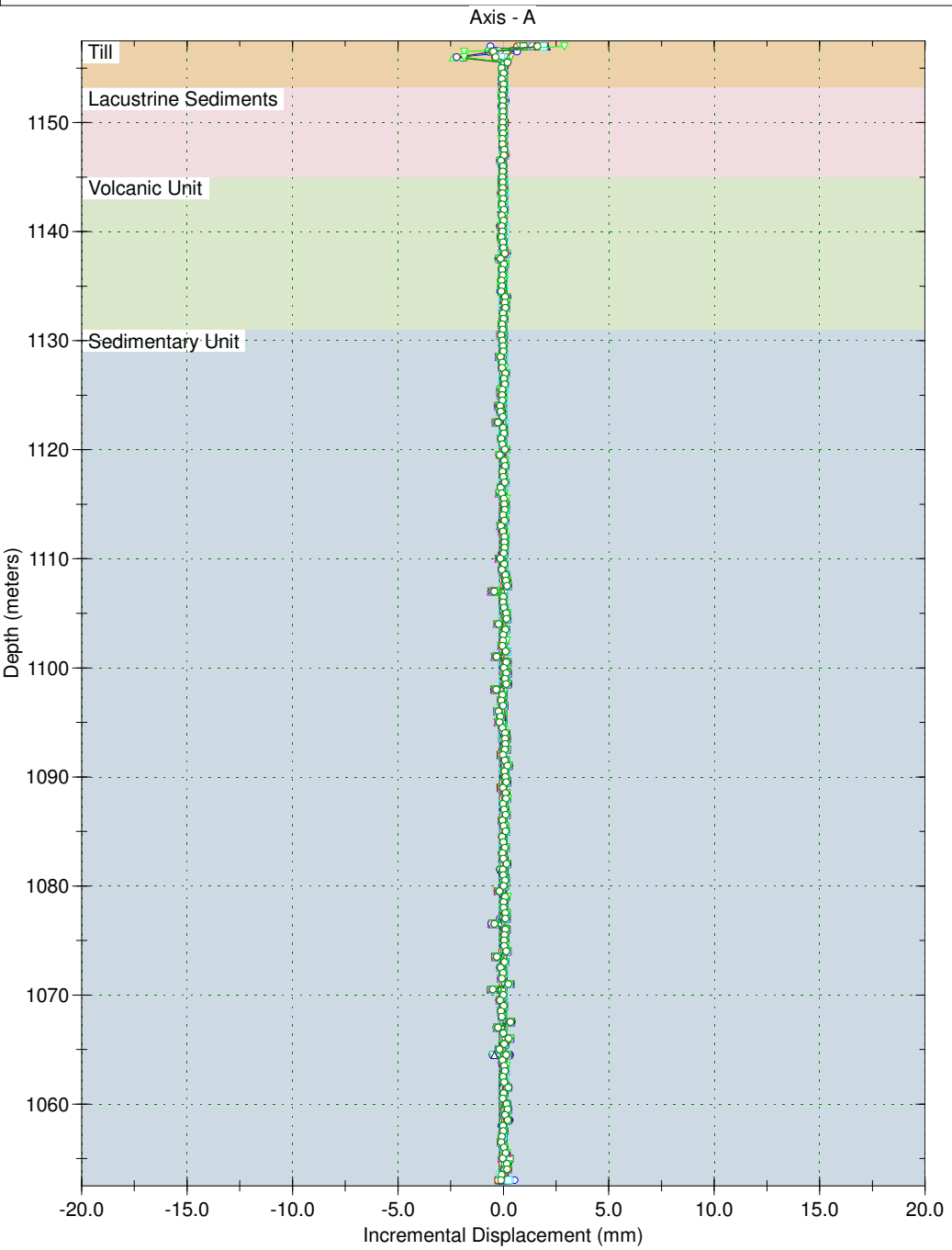
RST Instruments Ltd.

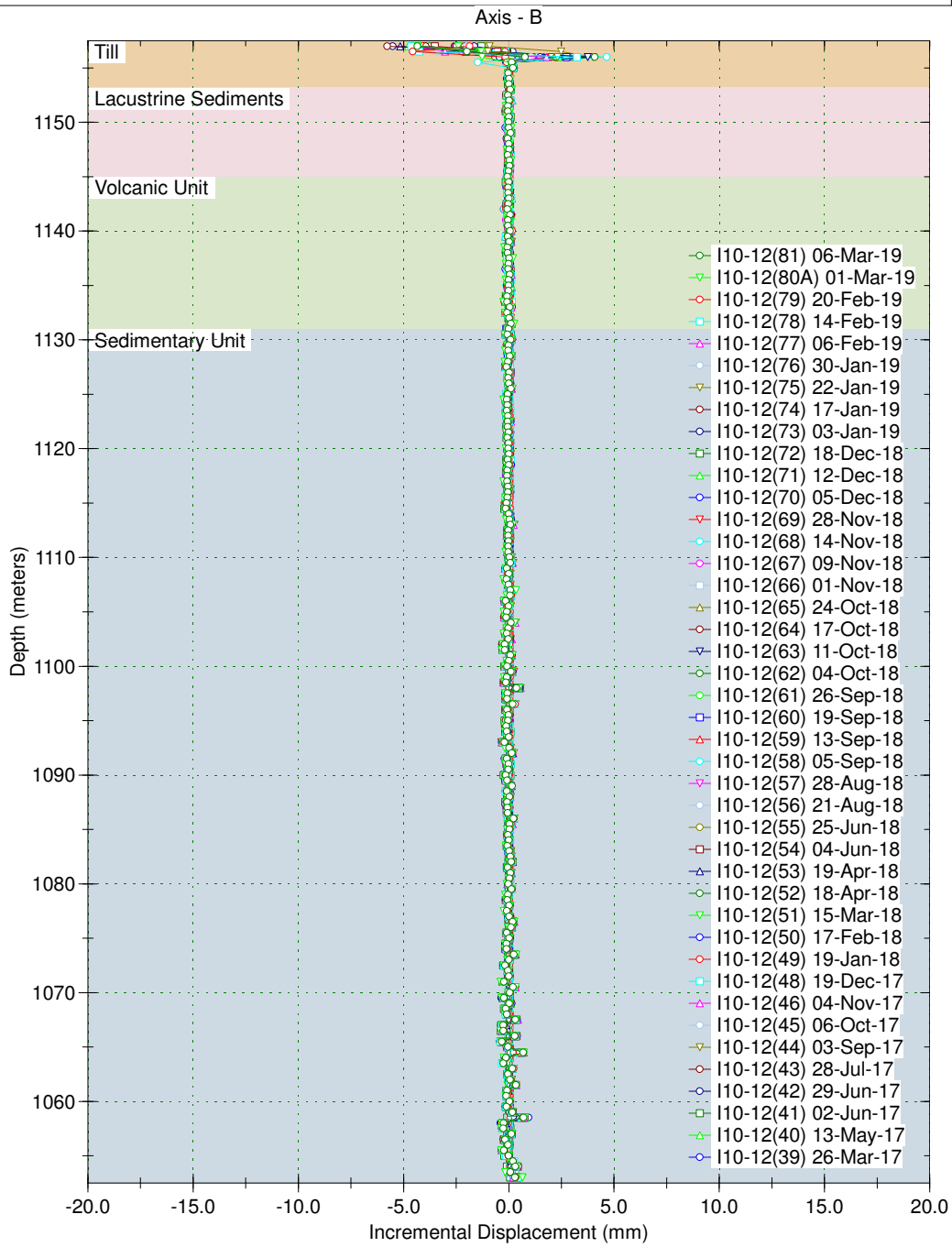
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I10-12
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1157.50 meters
Reading Depth : 104.5 meters
A+ Groove Azimuth :
Base Reading : 2017 Jan 27 16:23
Applied Azimuth : 0.0 degrees





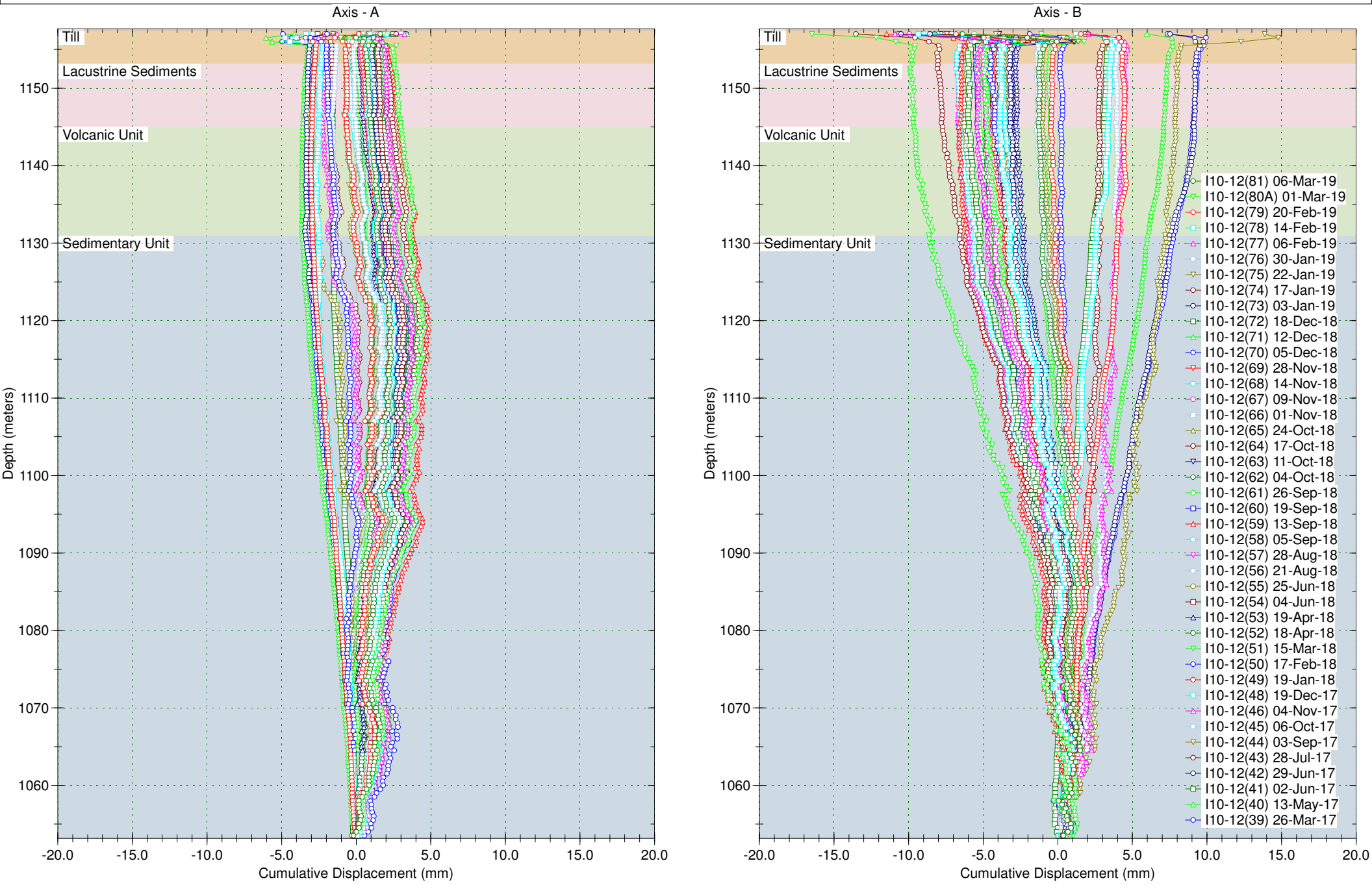
RST Instruments Ltd.

CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I10-12
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1157.50 meters
Reading Depth : 104.5 meters
A+ Groove Azimuth :
Base Reading : 2017 Jan 27 16:23
Applied Azimuth : 0.0 degrees



North Buttress Berm

I15-25

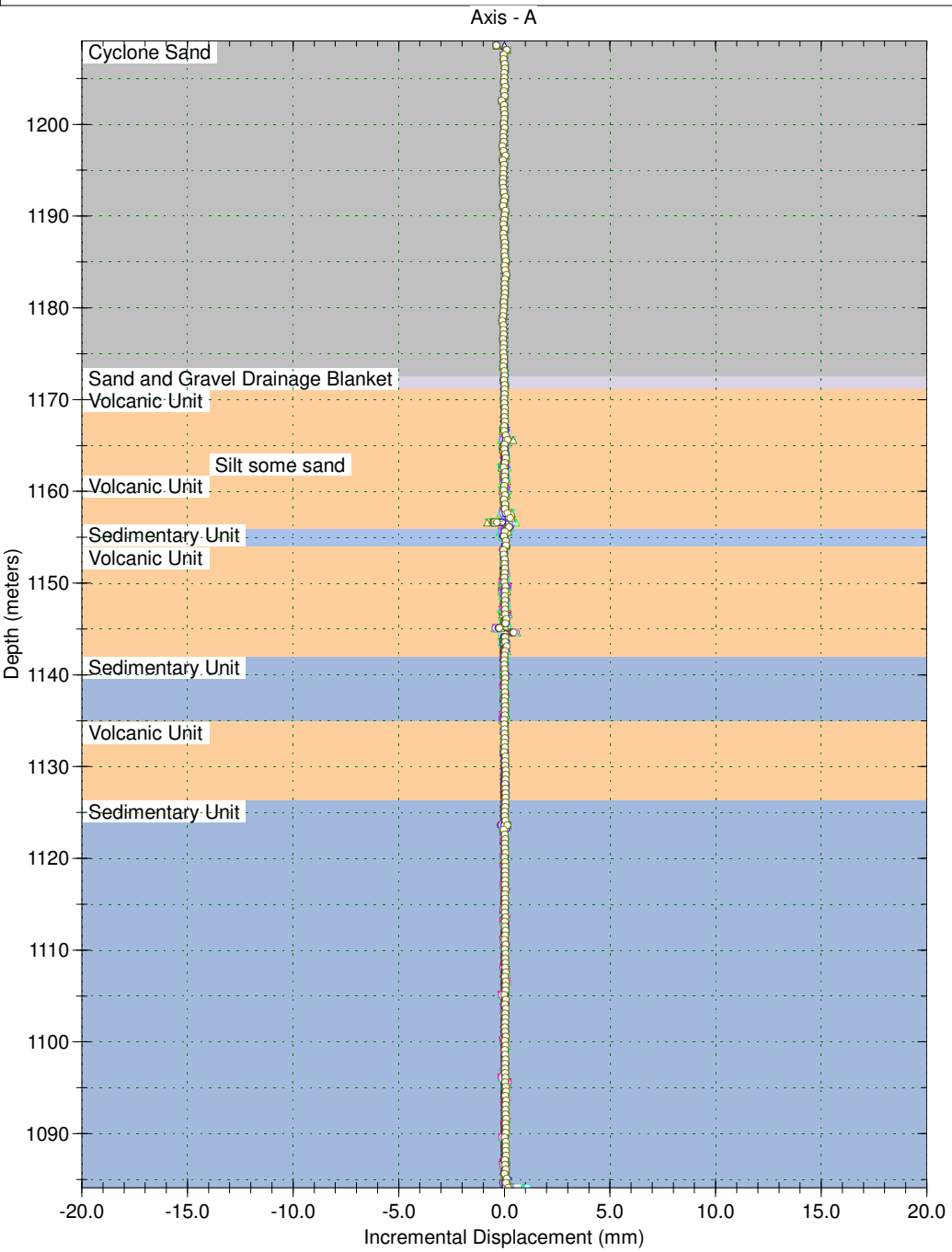
RST Instruments Ltd.

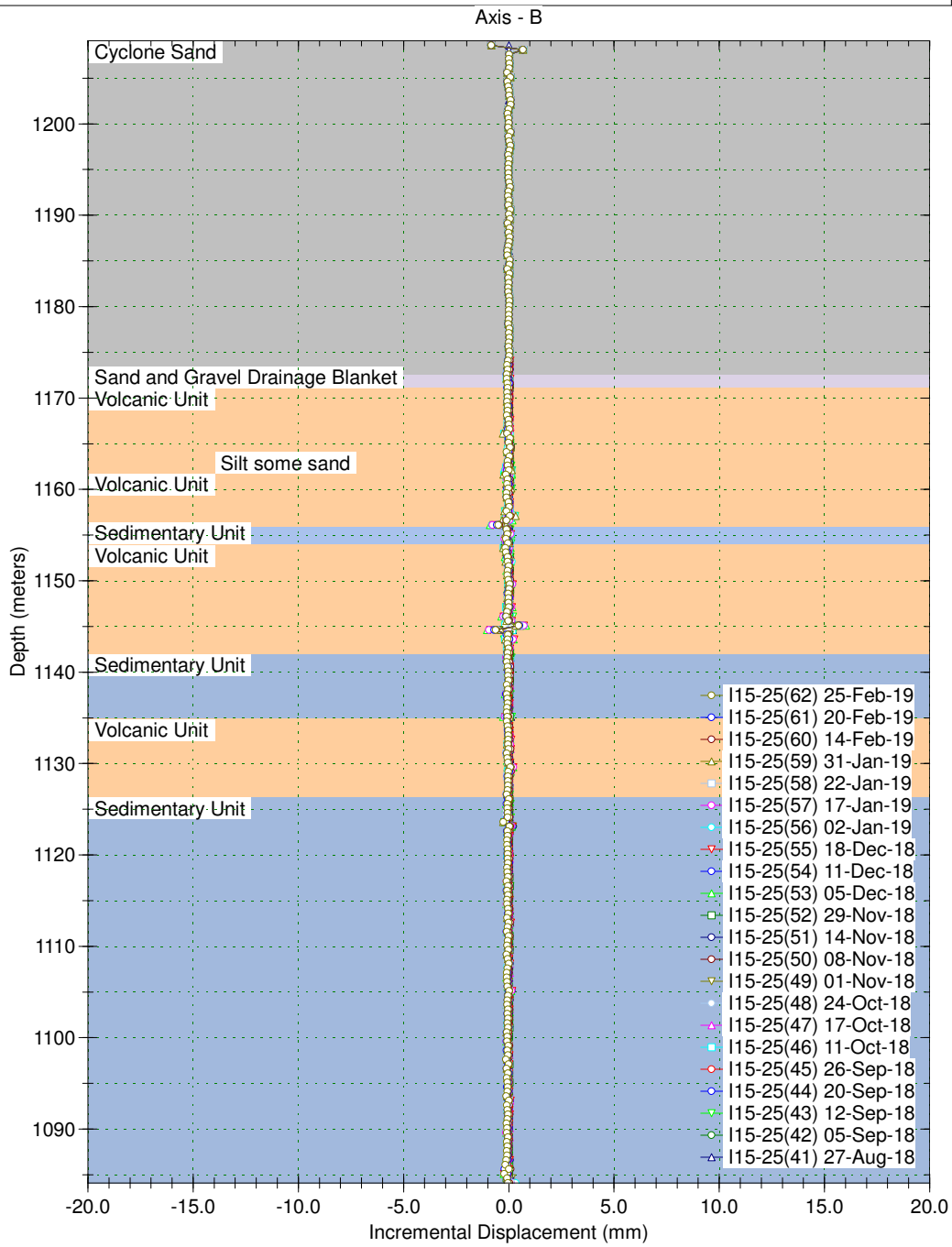
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I15-25
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : Enabled
Collar Elevation : :1209.10 meters
Reading Depth : 125.0 meters
A+ Groove Azimuth :
Base Reading : 2018 Aug 21 14:01
Applied Azimuth : 0.0 degrees





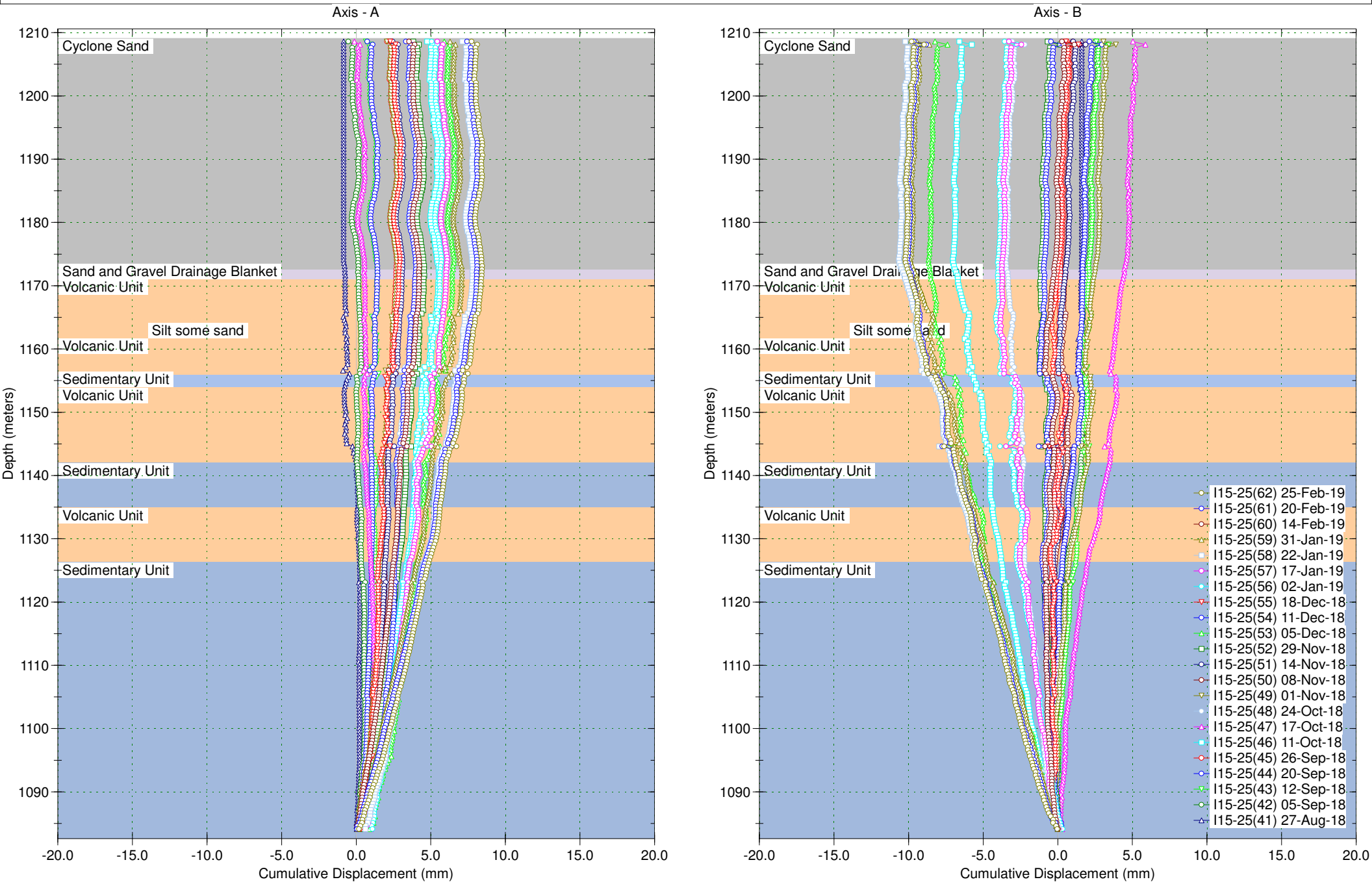
RST Instruments Ltd.

CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I15-25
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : Enabled
Collar Elevation : :1209.10 meters
Reading Depth : 125.0 meters
A+ Groove Azimuth :
Base Reading : 2018 Aug 21 14:01
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

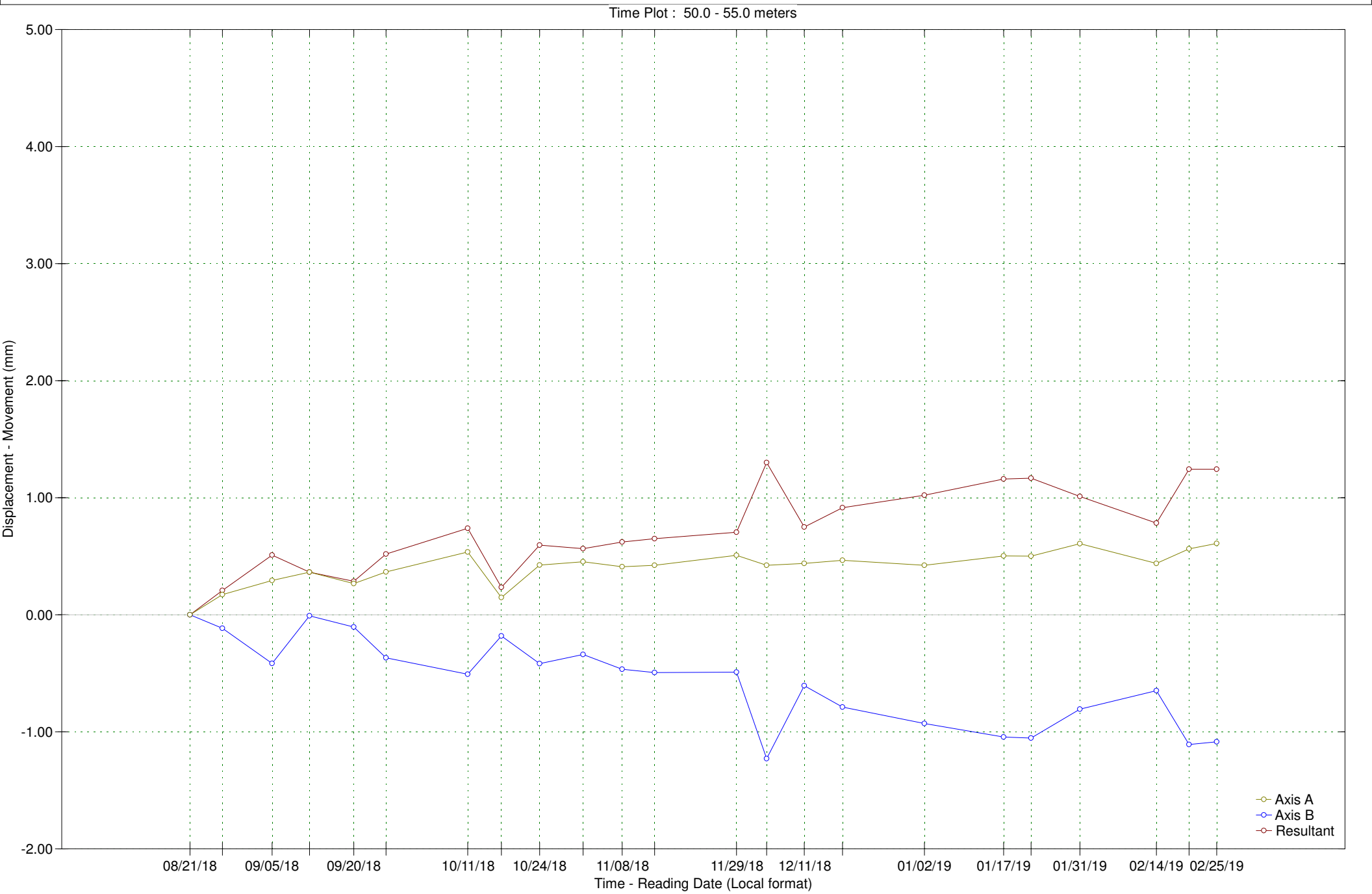
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I15-25
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1209.10 meters

Spiral Correction : Enabled
Movement Depth : 50.0 - 55.0 meters
Reading Depth : 125.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 25 11:19
Initial Reading : 2018 Aug 21 14:01
Applied Azimuth : 0.0 degrees



NORTH BUTTRESS BERM

I17-22

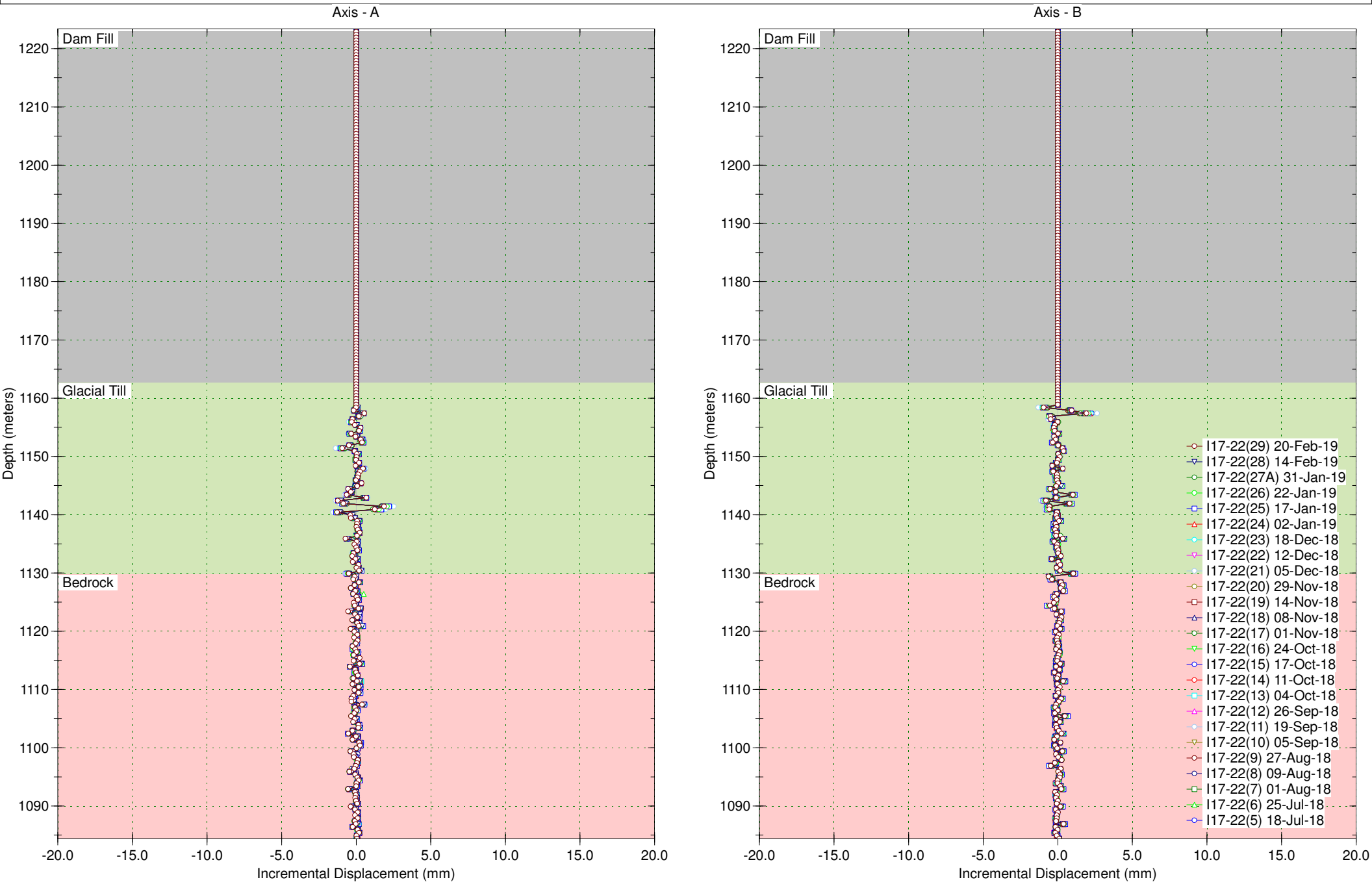
RST Instruments Ltd.

INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-22
Location :
Northing :
Easting :
Collar :

Spiral Correction : Enabled
Collar Elevation : :1223.40 meters
Reading Depth : 139.0 meters
A+ Groove Azimuth :
Base Reading : 2018 Apr 12 13:45
Applied Azimuth : 0.0 degrees



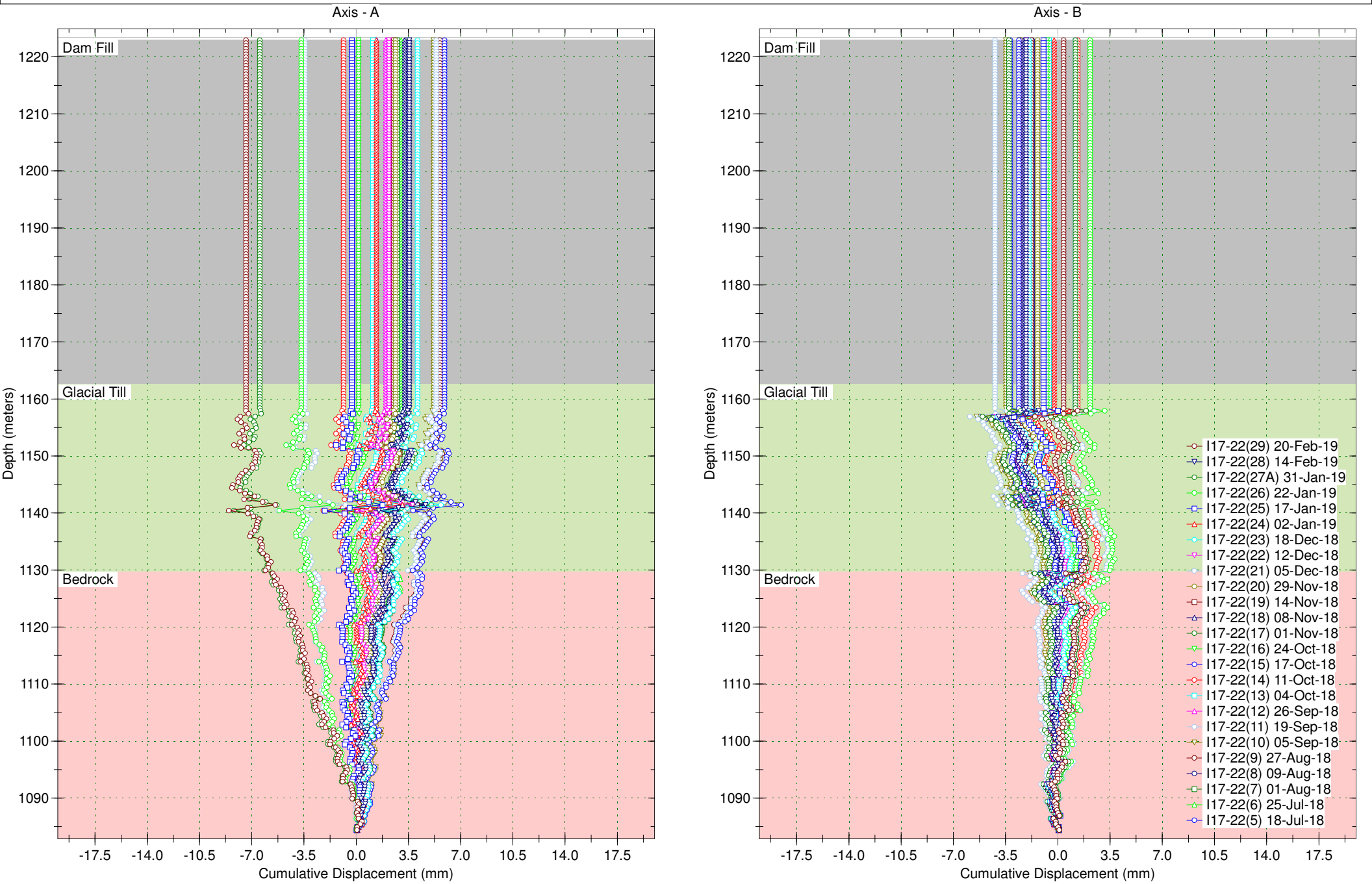
RST Instruments Ltd.

CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-22
Location :
Northing :
Easting :
Collar :

Spiral Correction : Enabled
Collar Elevation : :1223.40 meters
Reading Depth : 139.0 meters
A+ Groove Azimuth :
Base Reading : 2018 Apr 12 13:45
Applied Azimuth : 0.0 degrees



NORTH BUTTRESS BERM

I17-24

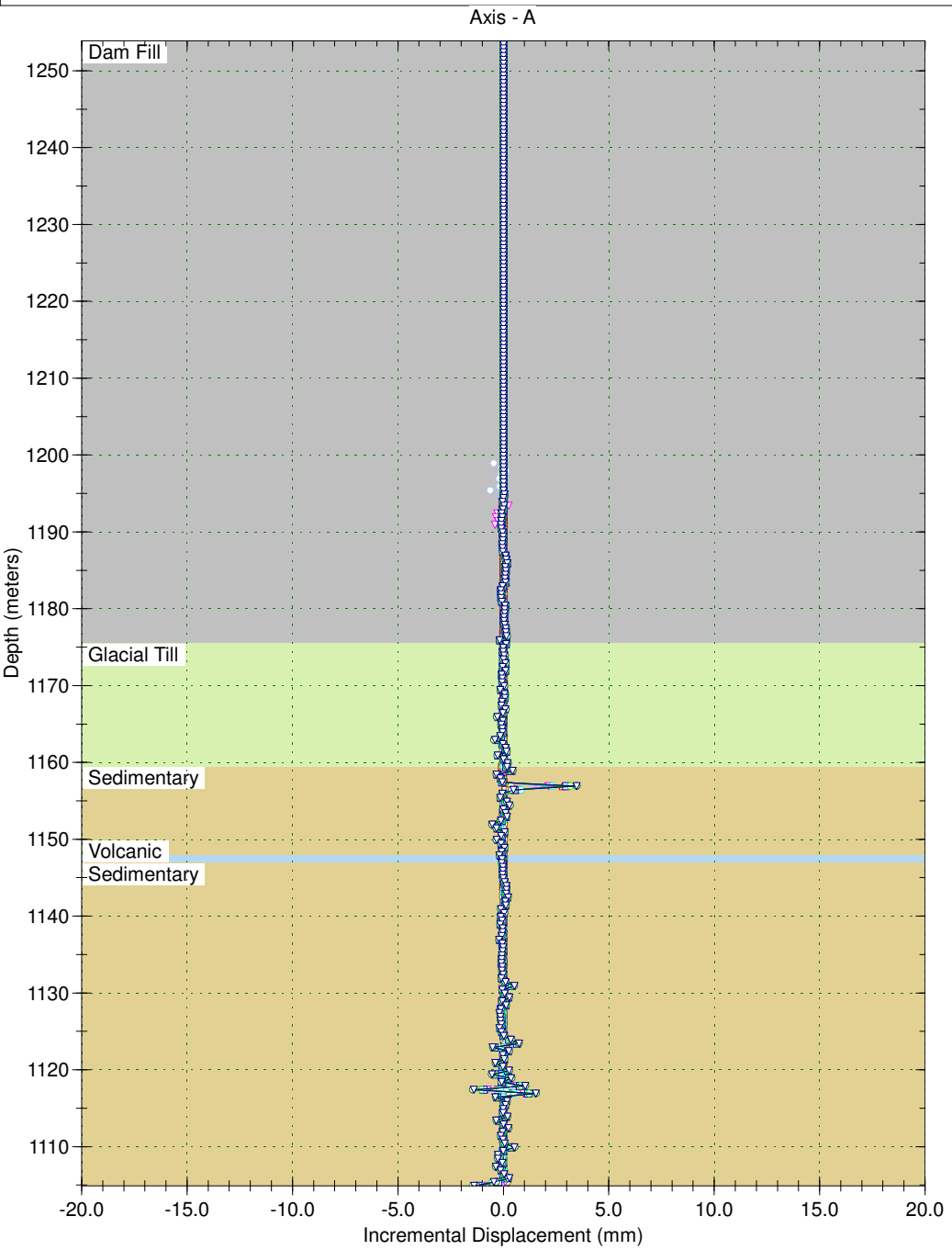
RST Instruments Ltd.

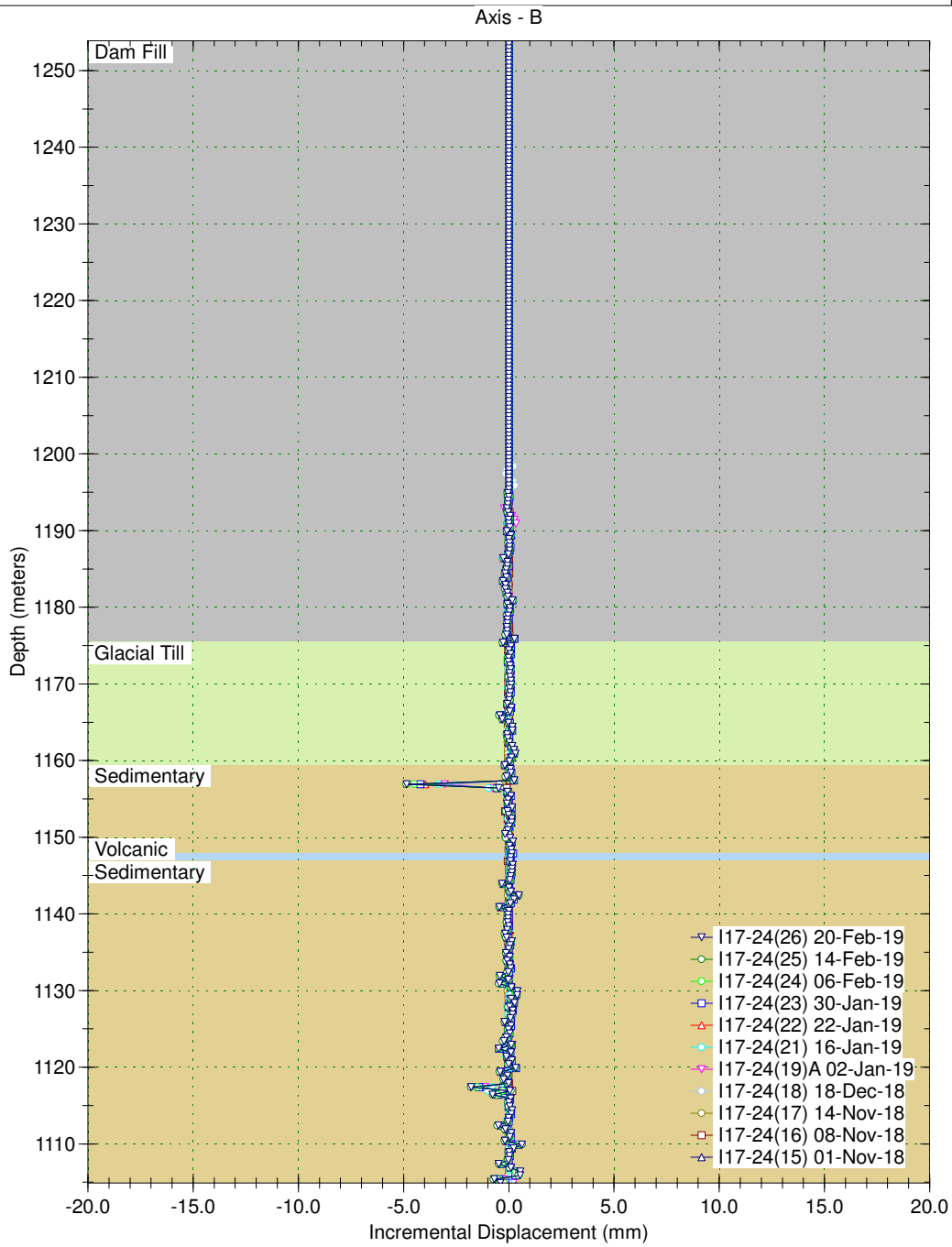
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-24
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1253.90 meters
Reading Depth : 149.0 meters
A+ Groove Azimuth :
Base Reading : 2018 Oct 24 12:11
Applied Azimuth : 0.0 degrees





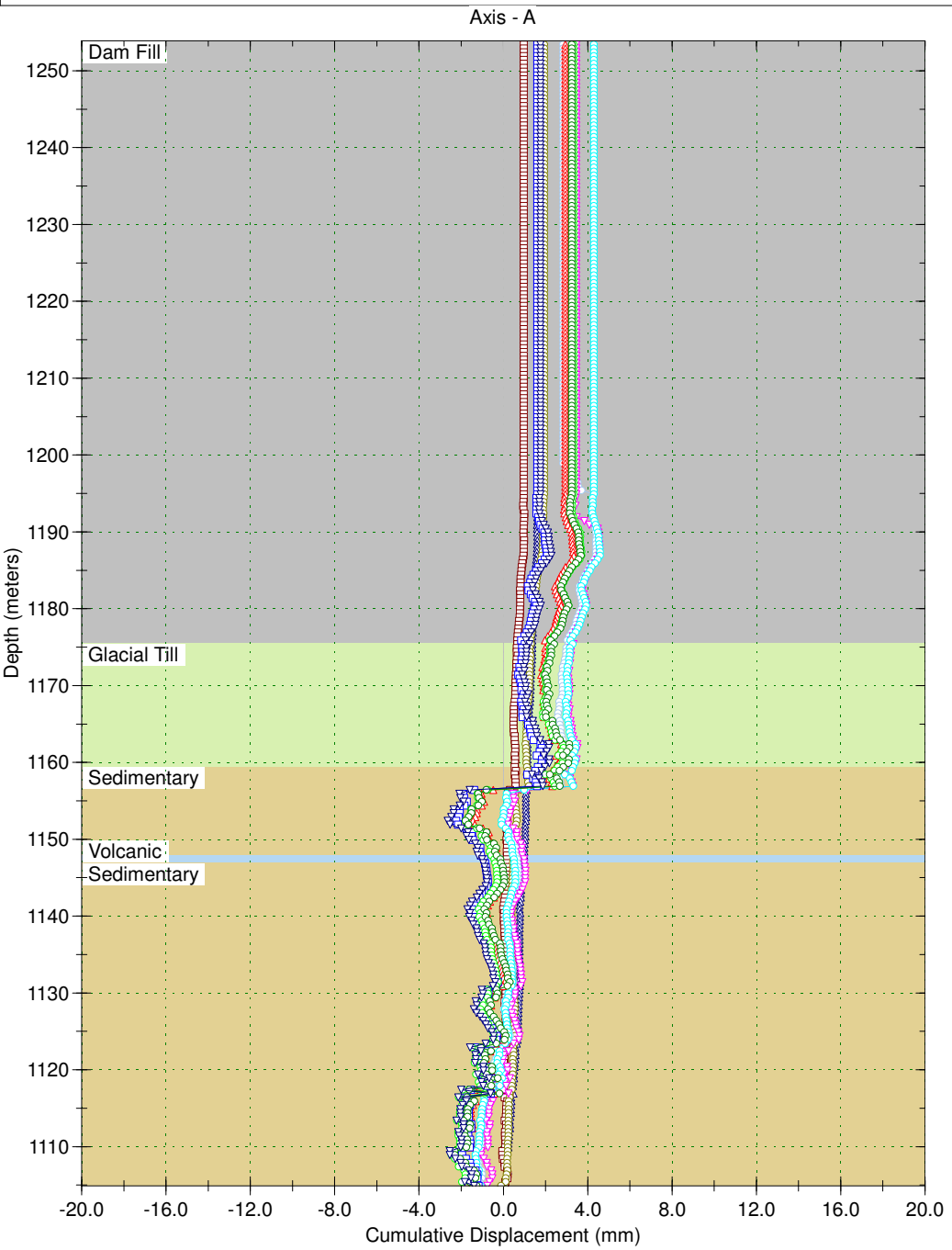
RST Instruments Ltd.

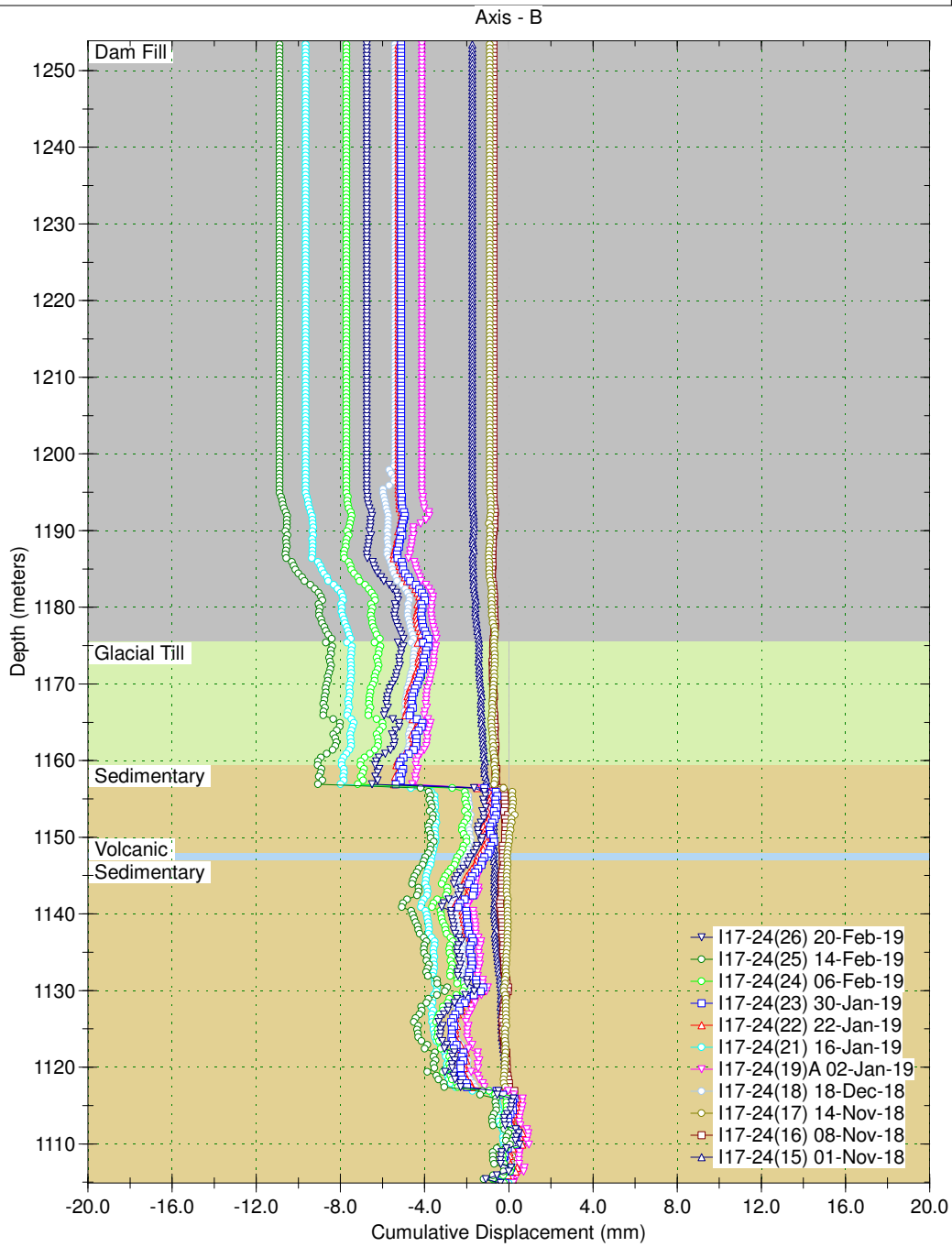
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-24
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1253.90 meters
Reading Depth : 149.0 meters
A+ Groove Azimuth :
Base Reading : 2018 Oct 24 12:11
Applied Azimuth : 0.0 degrees





RST Instruments Ltd.

TIME PLOT

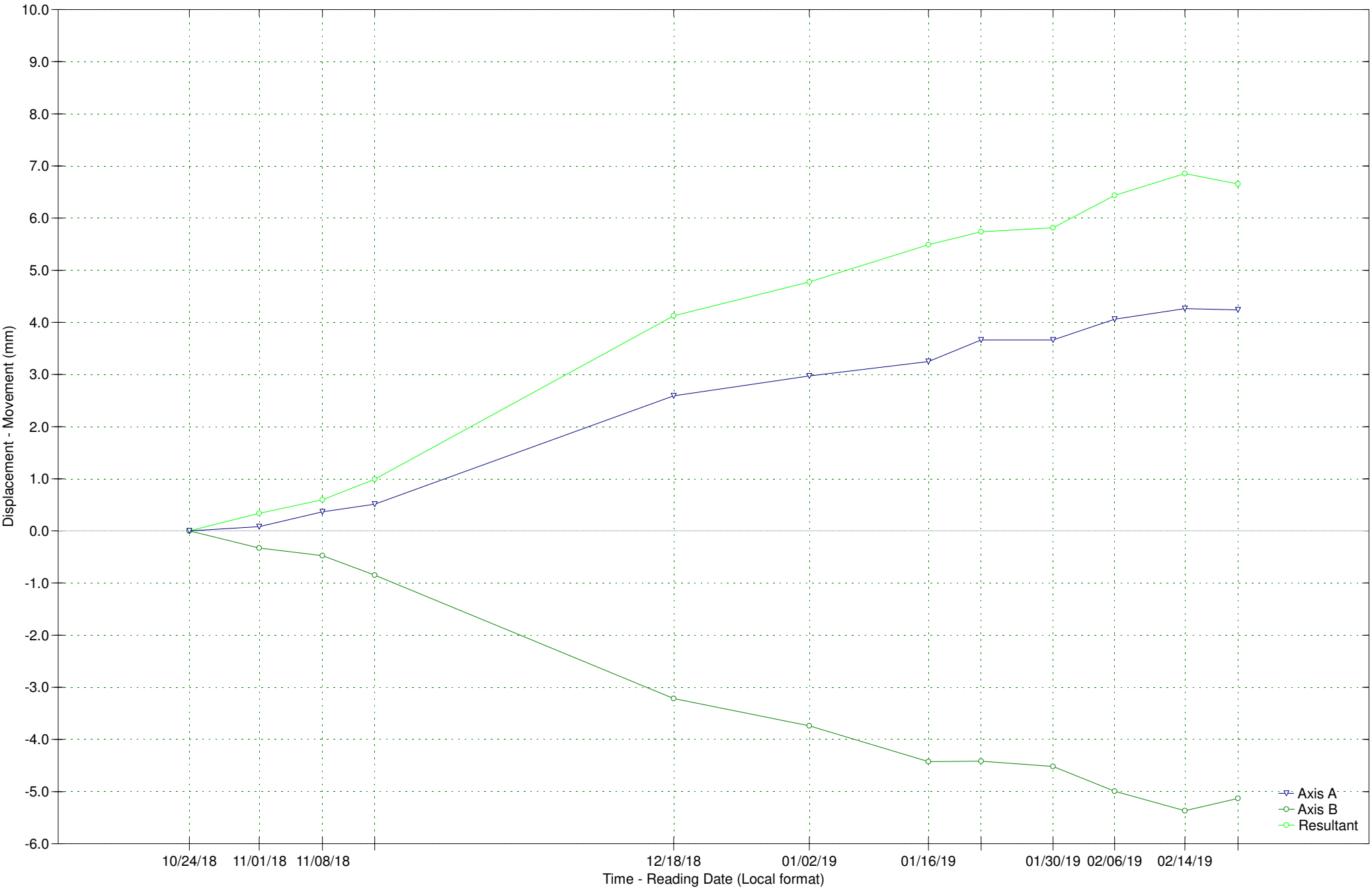
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-24
Location :
Northing :
Easting :
Collar :
Collar Elev : 1253.90 meters

Spiral Correction : N/A
Movement Depth : 94.0 - 99.0 meters
Reading Depth : 149.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 20 14:14
Initial Reading : 2018 Oct 24 12:11
Applied Azimuth : 0.0 degrees

Time Plot : 94.0 - 99.0 meters



VALLEY BUTTRESS BERM EXTENSION

I10-05

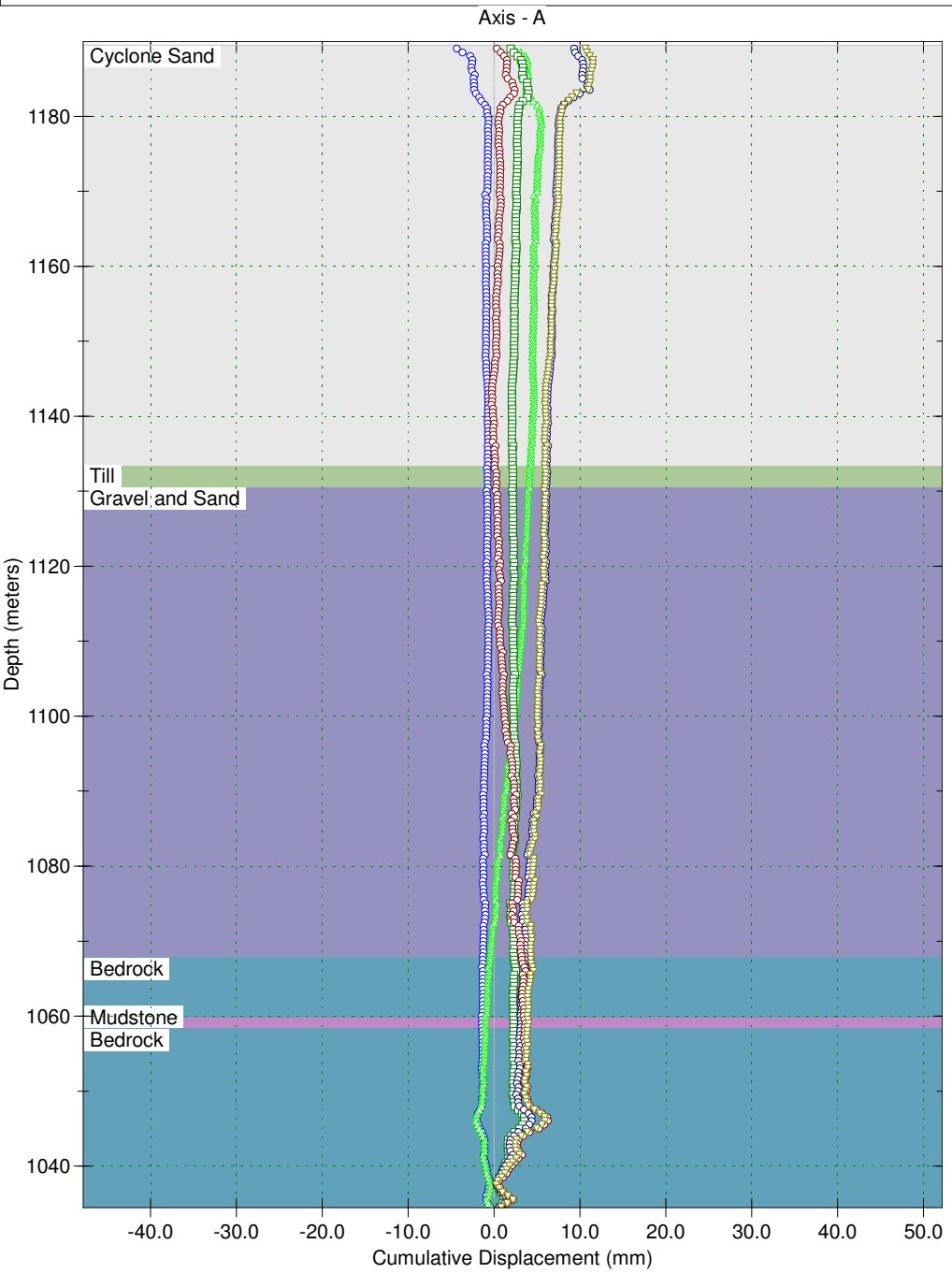
RST Instruments Ltd.

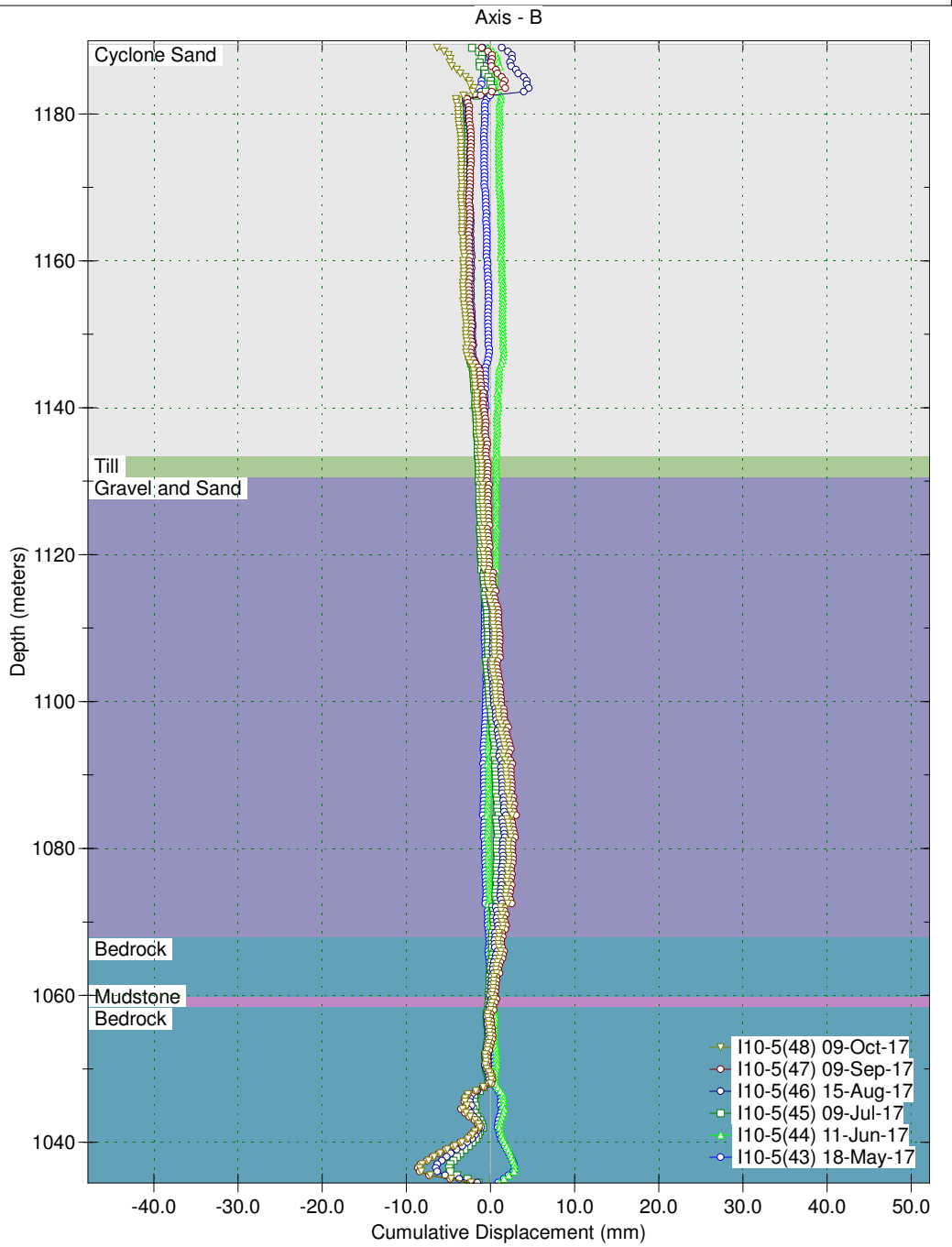
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I10-5
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1189.50 meters
Reading Depth : 155.5 meters
A+ Groove Azimuth :
Base Reading : 2017 Apr 13 14:27
Applied Azimuth : 0.0 degrees





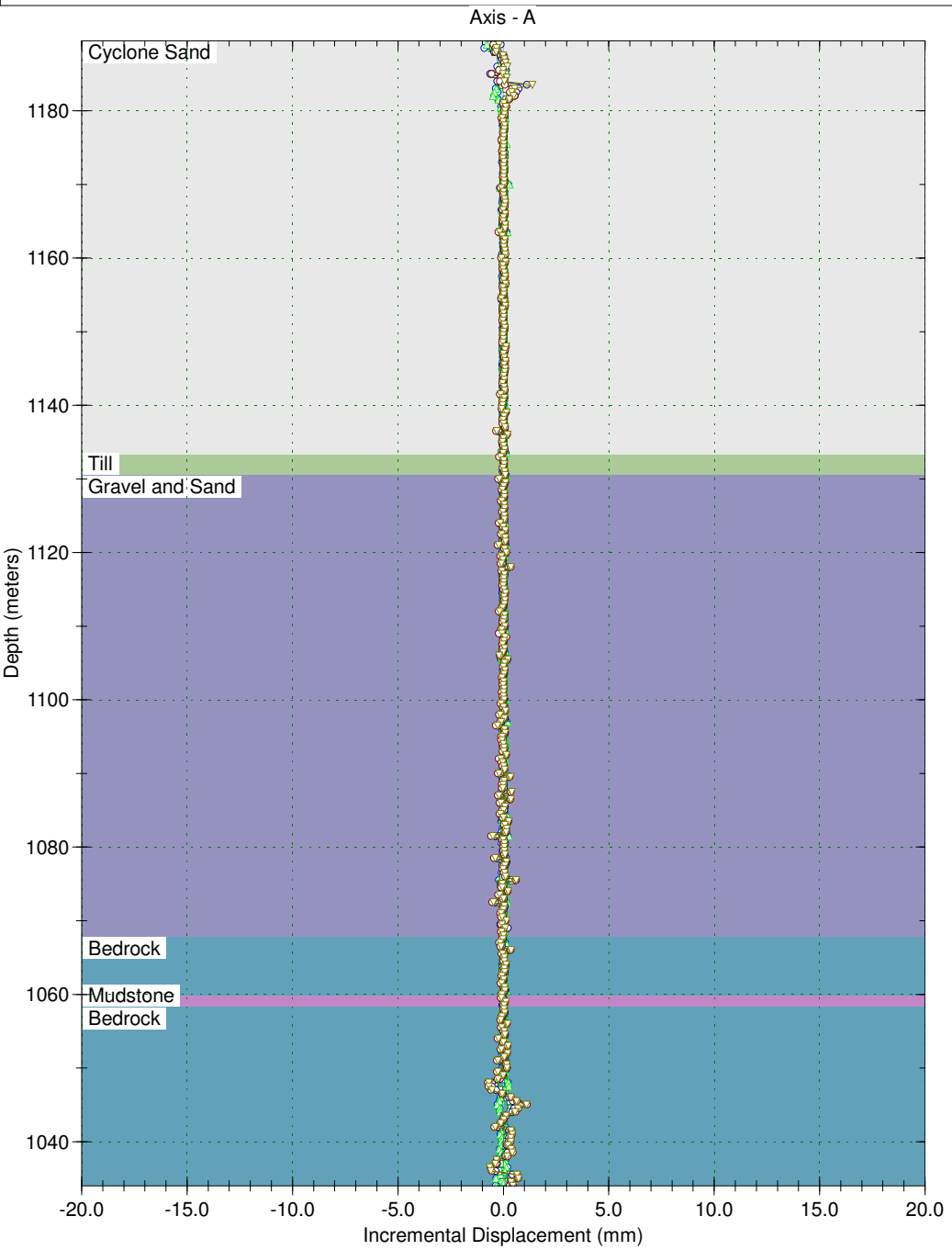
RST Instruments Ltd.

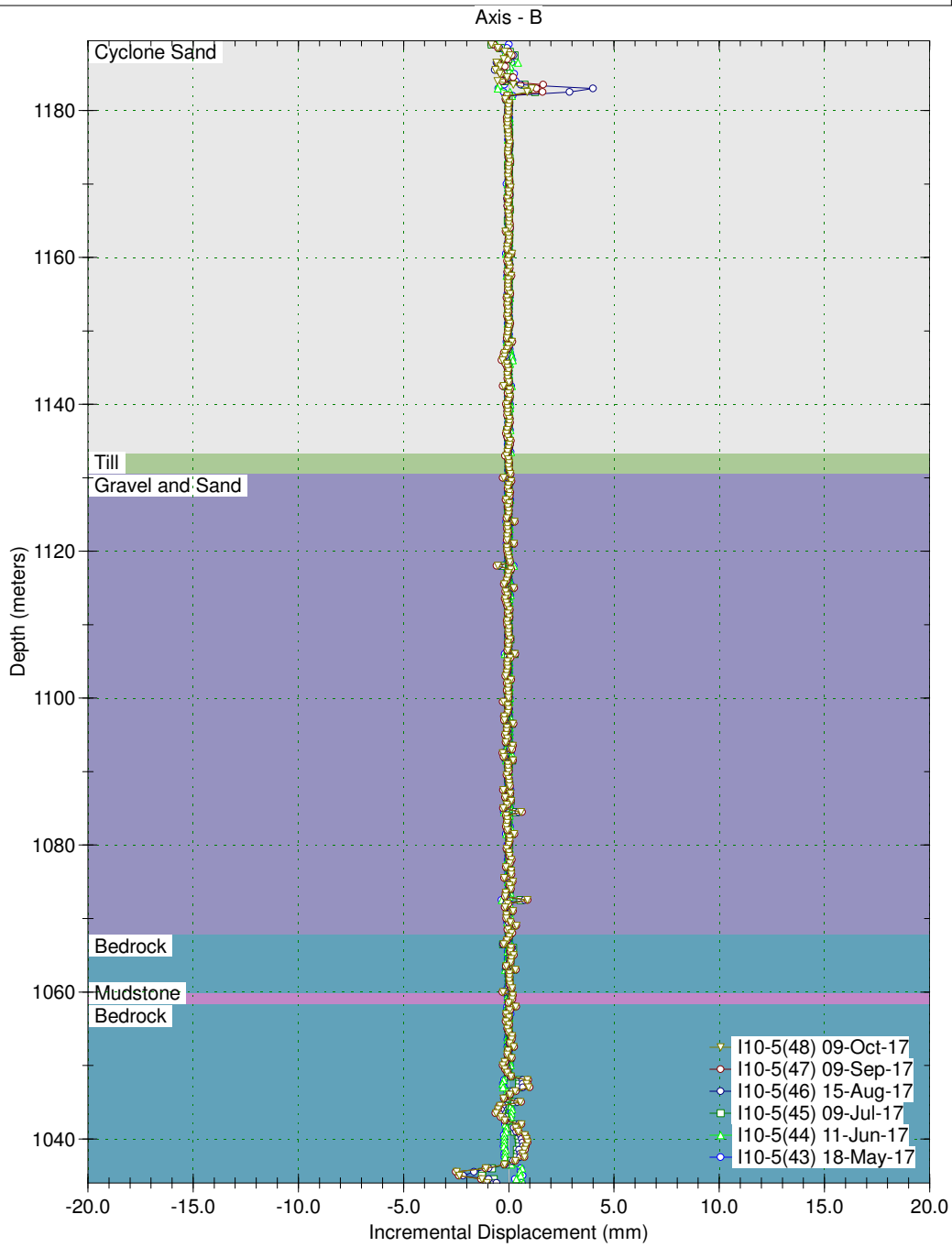
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I10-5
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1189.50 meters
Reading Depth : 155.5 meters
A+ Groove Azimuth :
Base Reading : 2017 Apr 13 14:27
Applied Azimuth : 0.0 degrees





RST Instruments Ltd.

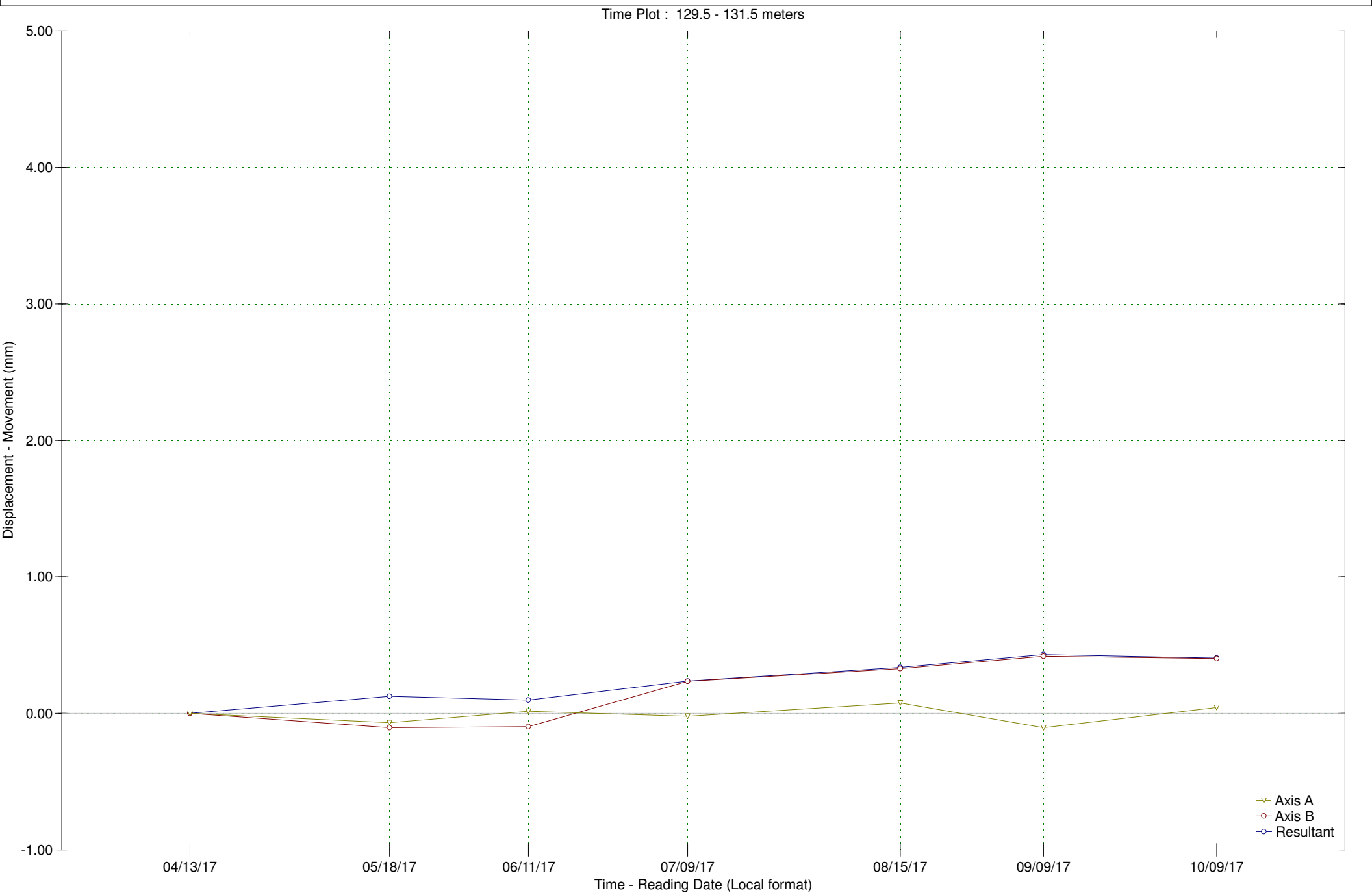
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I10-5
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1189.50 meters

Spiral Correction : N/A
Movement Depth : 129.5 - 131.5 meters
Reading Depth : 155.5 meters
A+ Groove Azimuth :
Latest Reading : 2017 Oct 09 18:03
Initial Reading : 2017 Apr 13 14:27
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

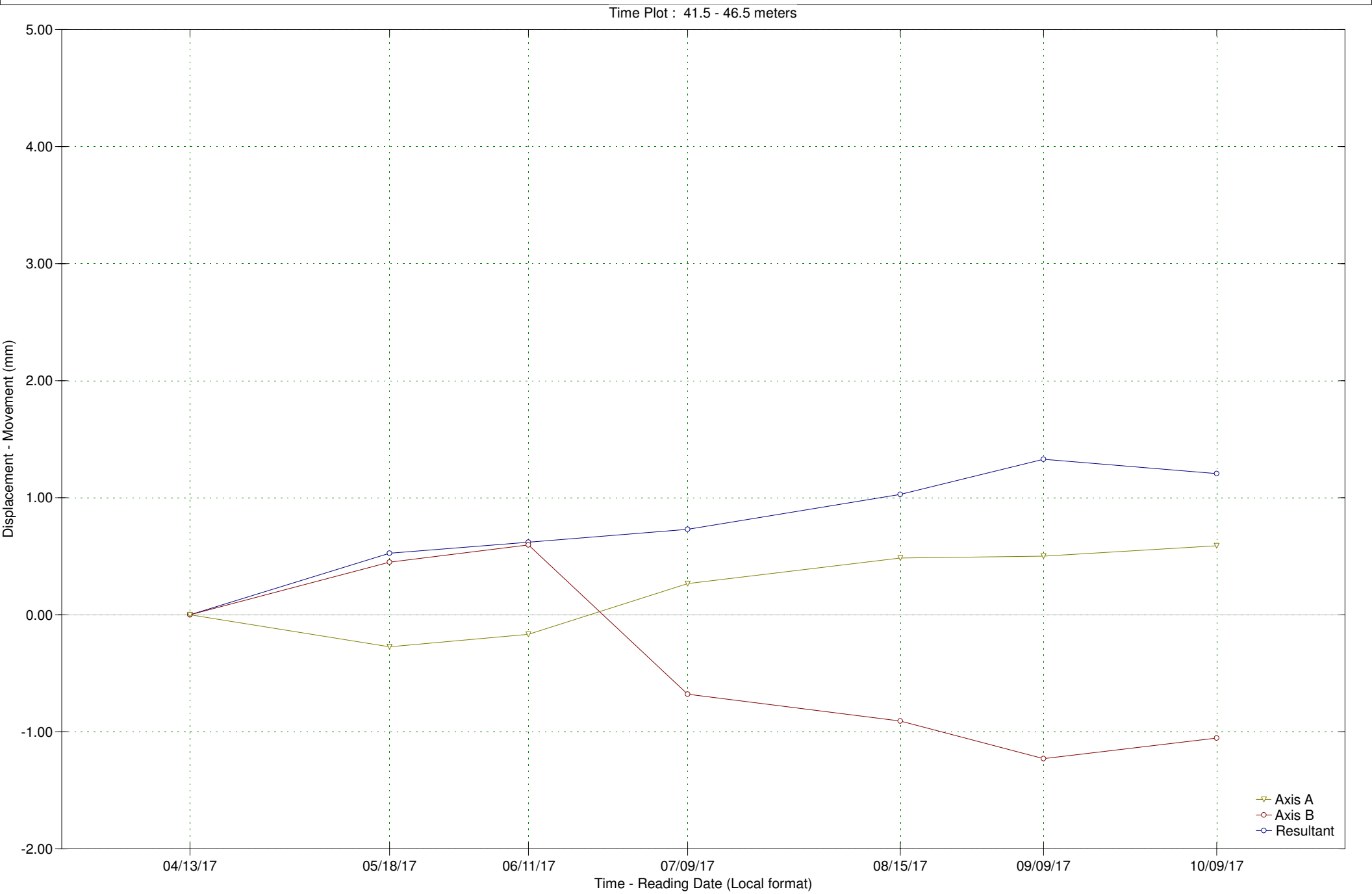
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I10-5
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1189.50 meters

Spiral Correction : N/A
Movement Depth : 41.5 - 46.5 meters
Reading Depth : 155.5 meters
A+ Groove Azimuth :
Latest Reading : 2017 Oct 09 18:03
Initial Reading : 2017 Apr 13 14:27
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

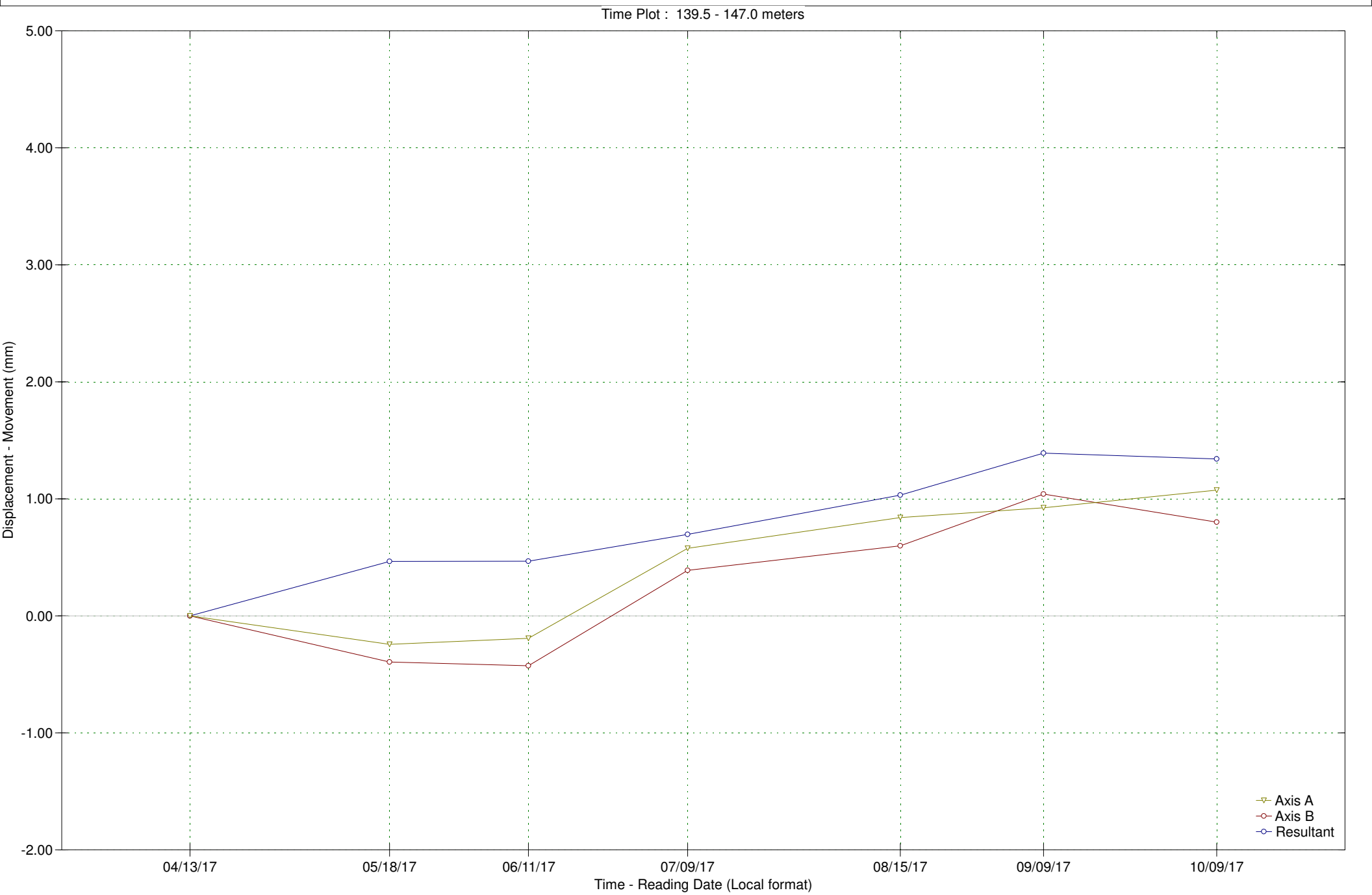
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I10-5
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1189.50 meters

Spiral Correction : N/A
Movement Depth : 139.5 - 147.0 meters
Reading Depth : 155.5 meters
A+ Groove Azimuth :
Latest Reading : 2017 Oct 09 18:03
Initial Reading : 2017 Apr 13 14:27
Applied Azimuth : 0.0 degrees



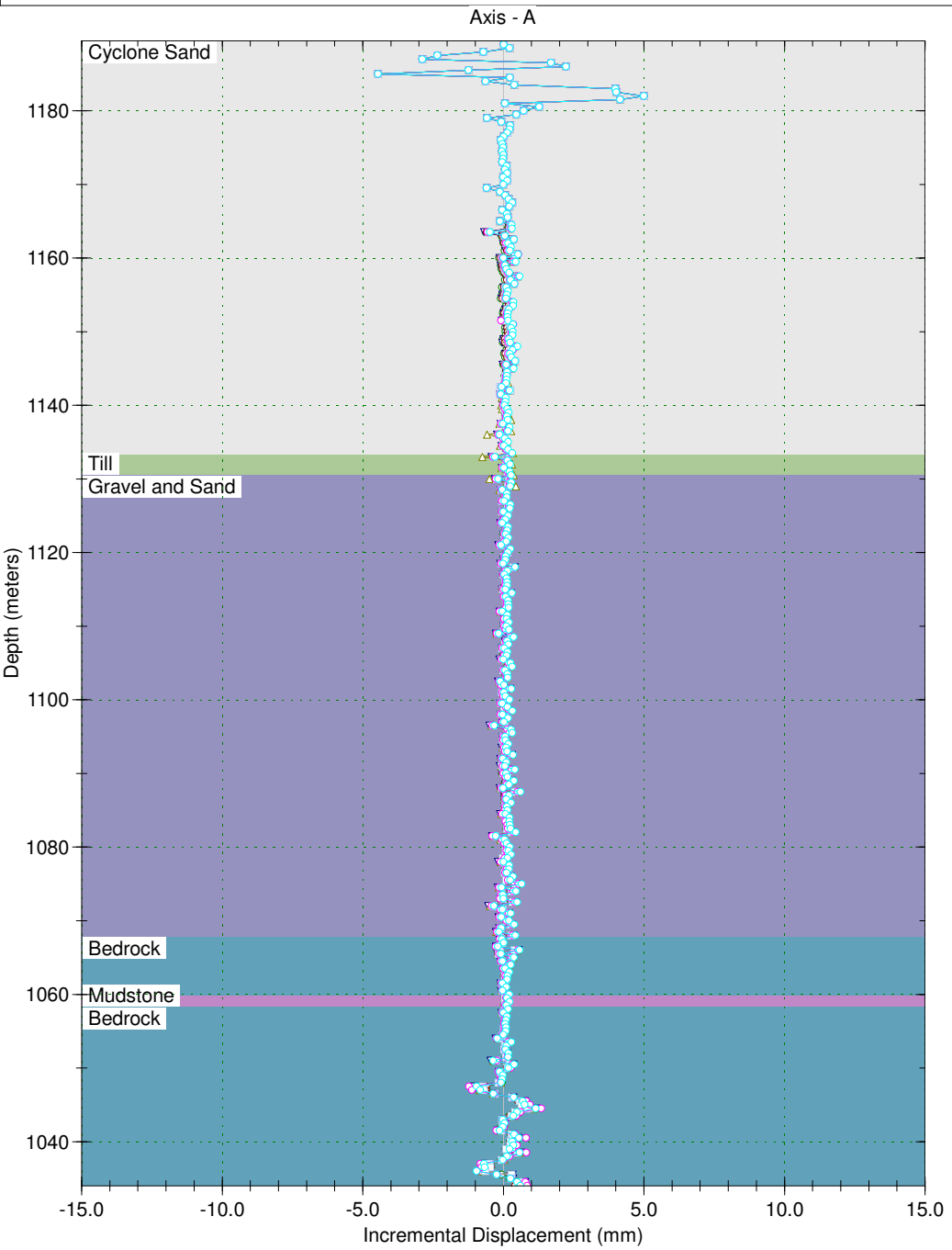
RST Instruments Ltd.

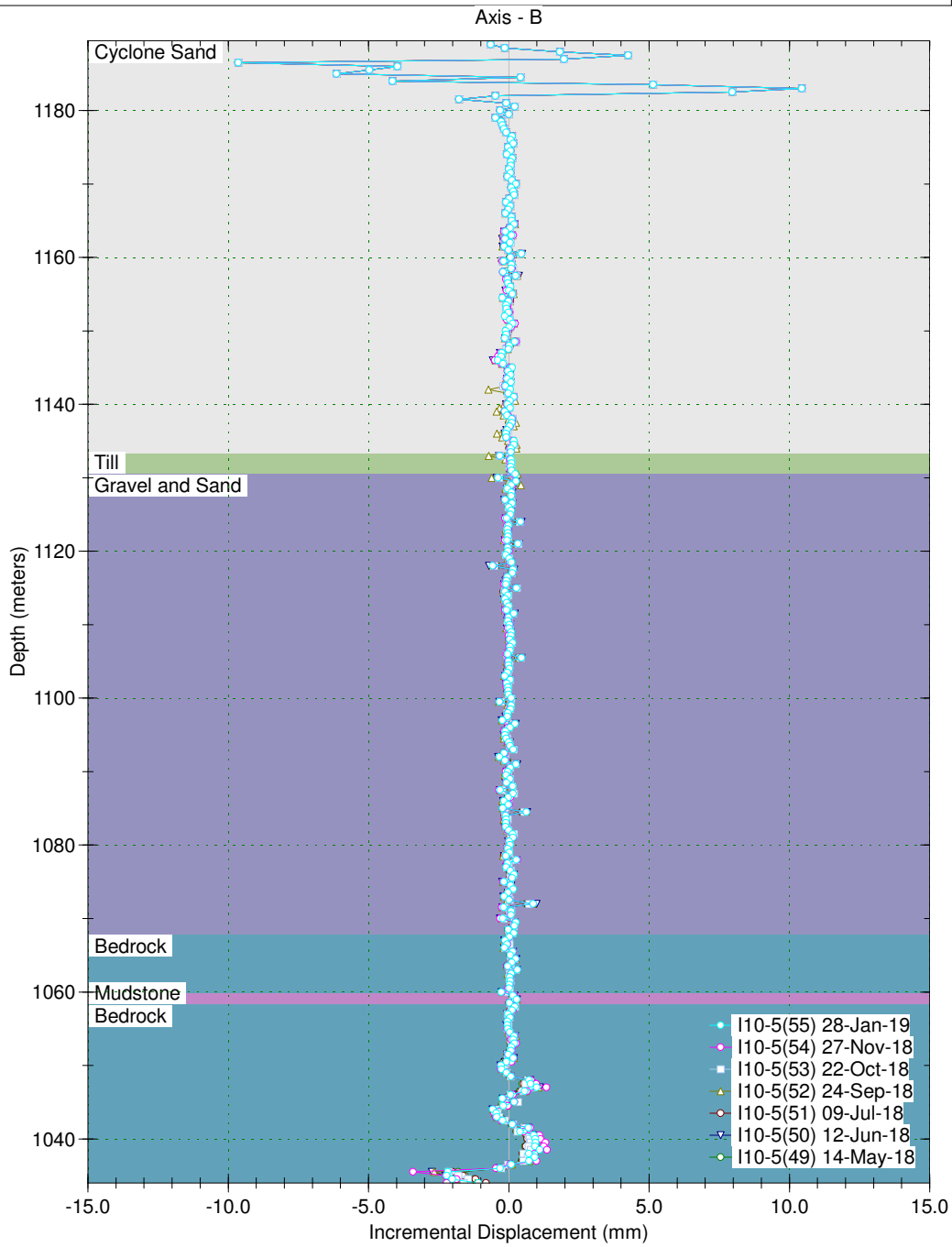
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I10-5
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1189.50 meters
Reading Depth : 155.5 meters
A+ Groove Azimuth :
Base Reading :
Applied Azimuth : 0.0 degrees





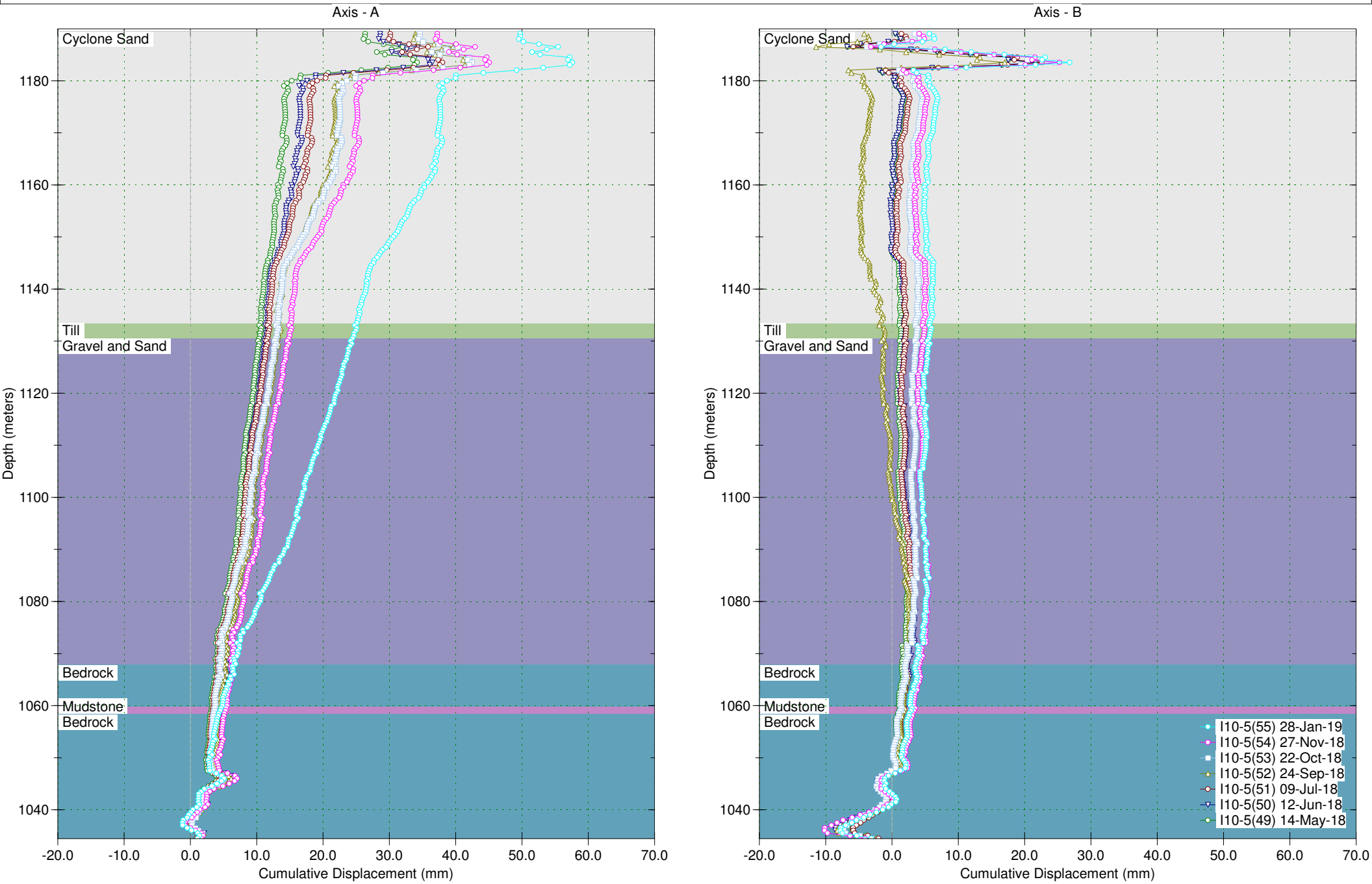
RST Instruments Ltd.

CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I10-5
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1189.50 meters
Reading Depth : 155.5 meters
A+ Groove Azimuth :
Base Reading :
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

TIME PLOT

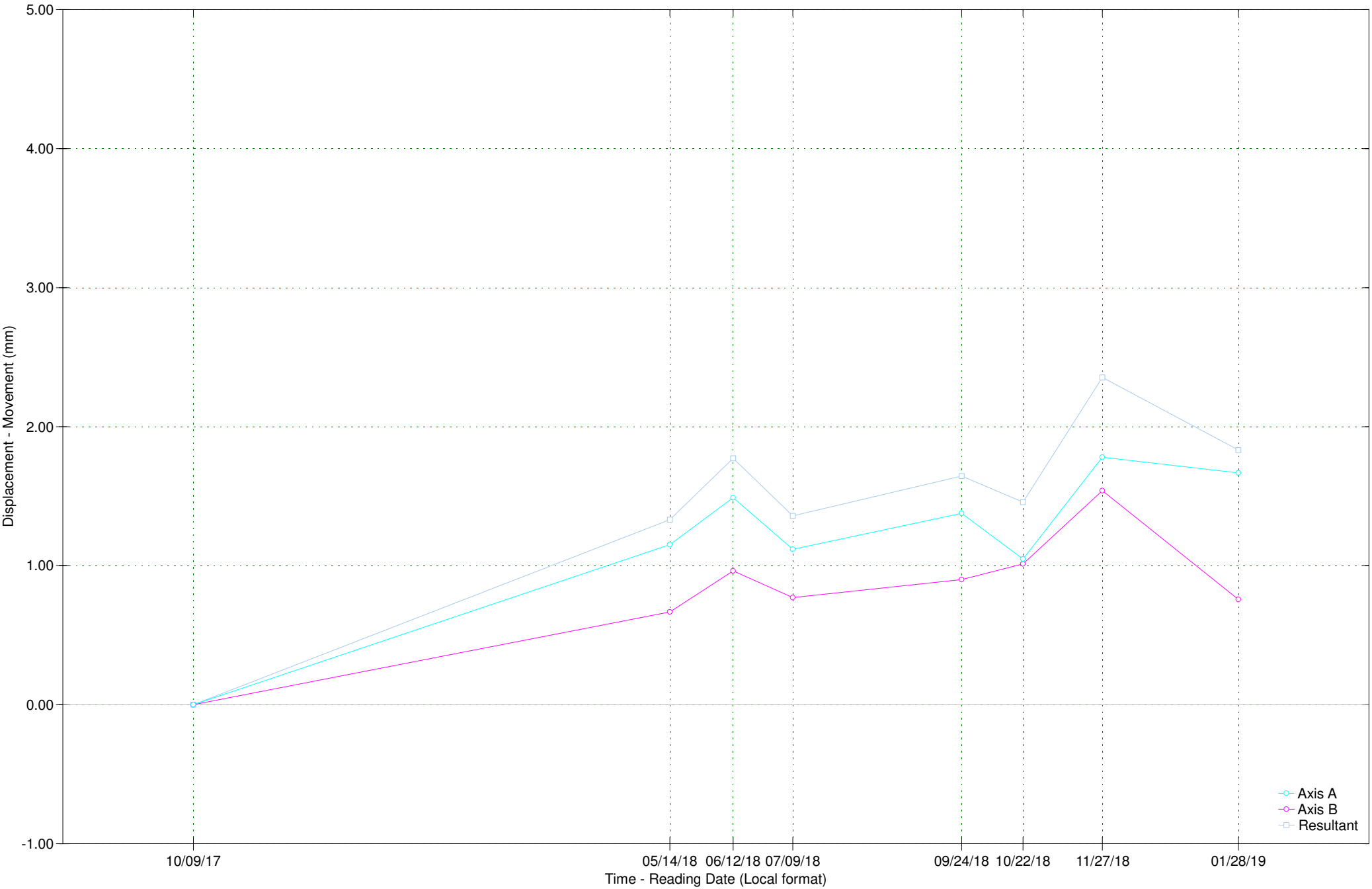
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I10-5
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1189.50 meters

Spiral Correction : N/A
Movement Depth : 139.5 - 147.0 meters
Reading Depth : 155.5 meters
A+ Groove Azimuth :
Latest Reading : 2019 Jan 28 09:35
Initial Reading : 2017 Oct 09 18:03
Applied Azimuth : 0.0 degrees

Time Plot : 139.5 - 147.0 meters



RST Instruments Ltd.

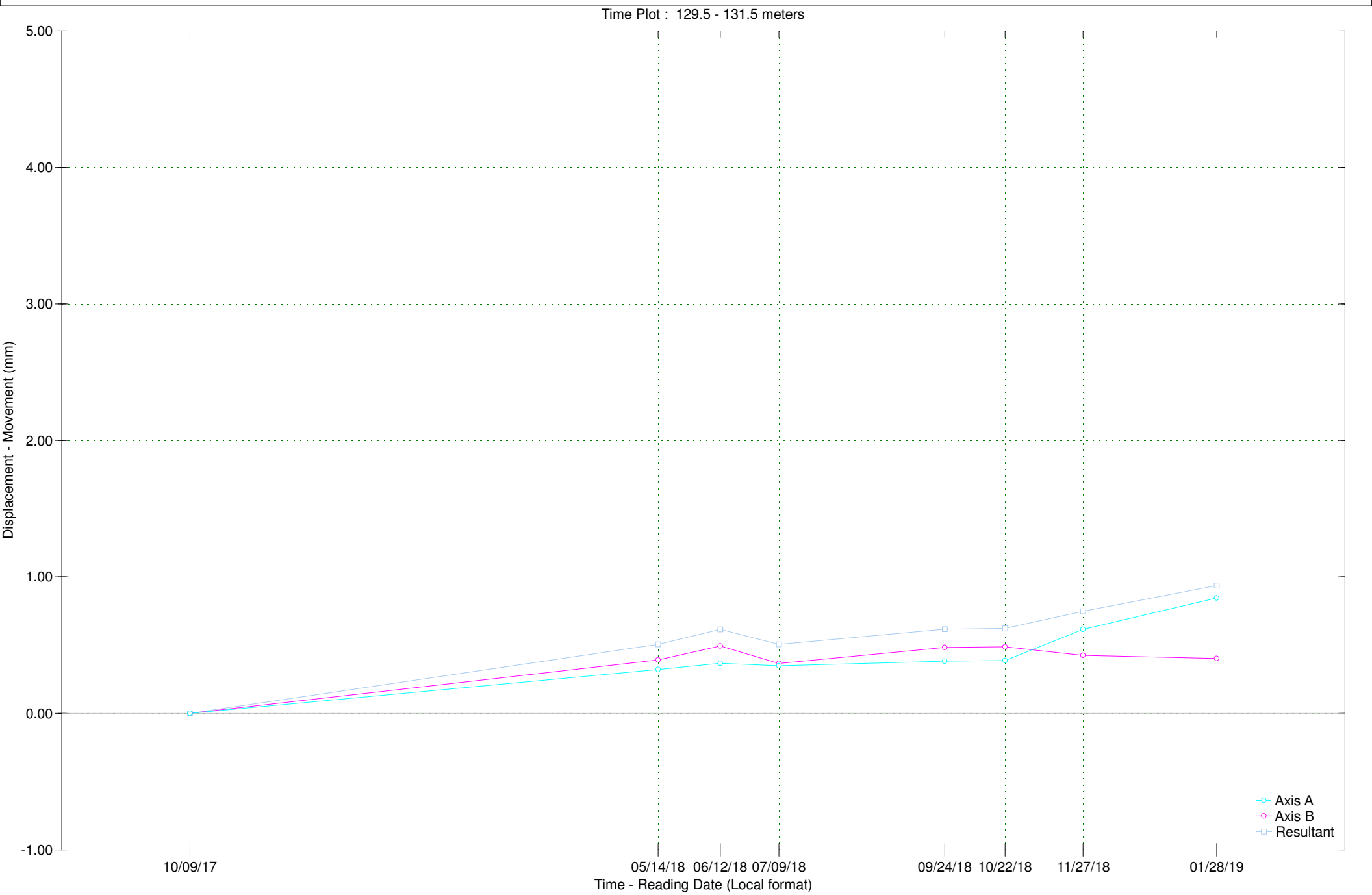
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I10-5
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1189.50 meters

Spiral Correction : N/A
Movement Depth : 129.5 - 131.5 meters
Reading Depth : 155.5 meters
A+ Groove Azimuth :
Latest Reading : 2019 Jan 28 09:35
Initial Reading : 2017 Oct 09 18:03
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

TIME PLOT

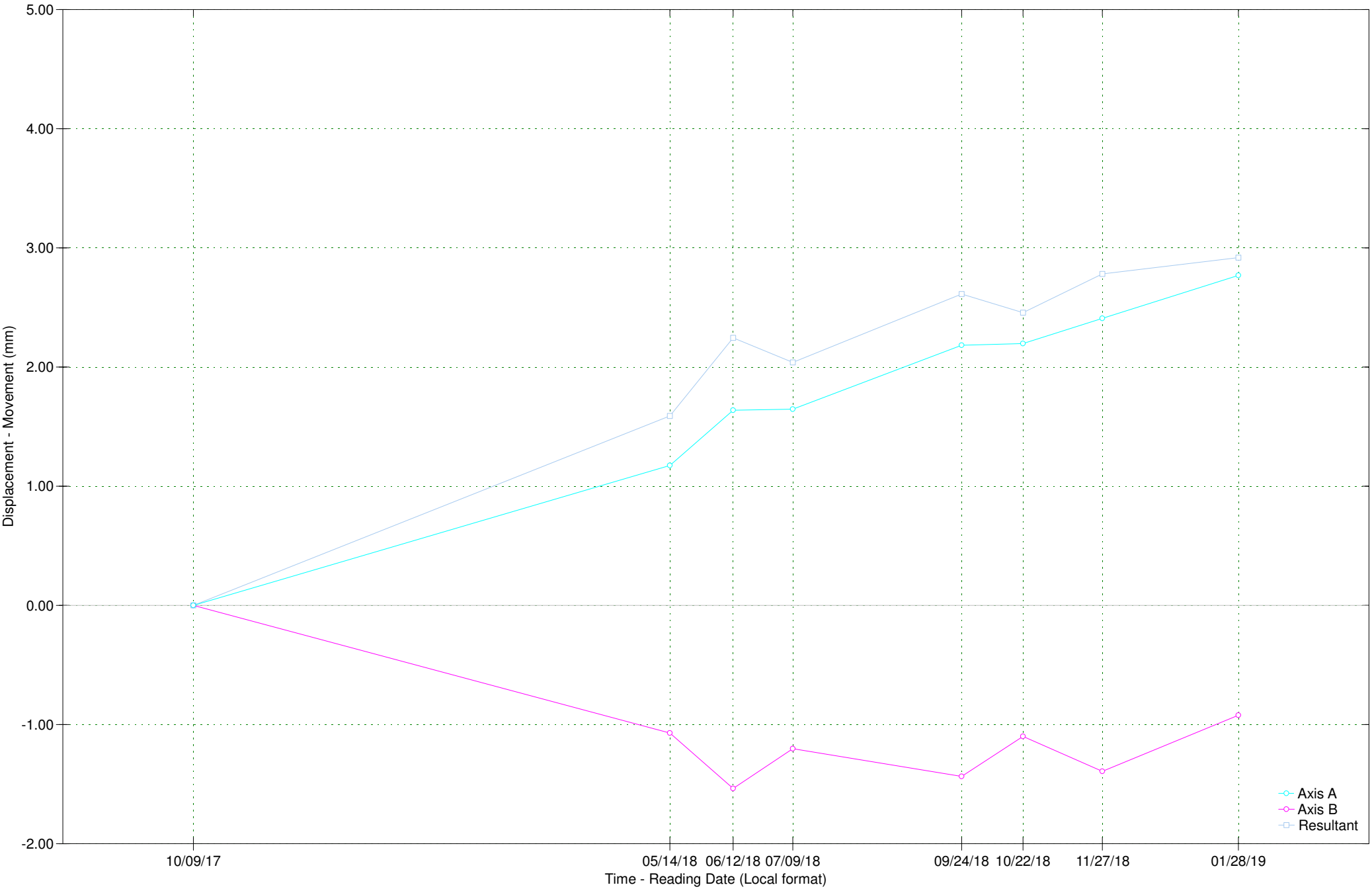
Displacement vs. Time

Inclinalysis v. 2.48.7

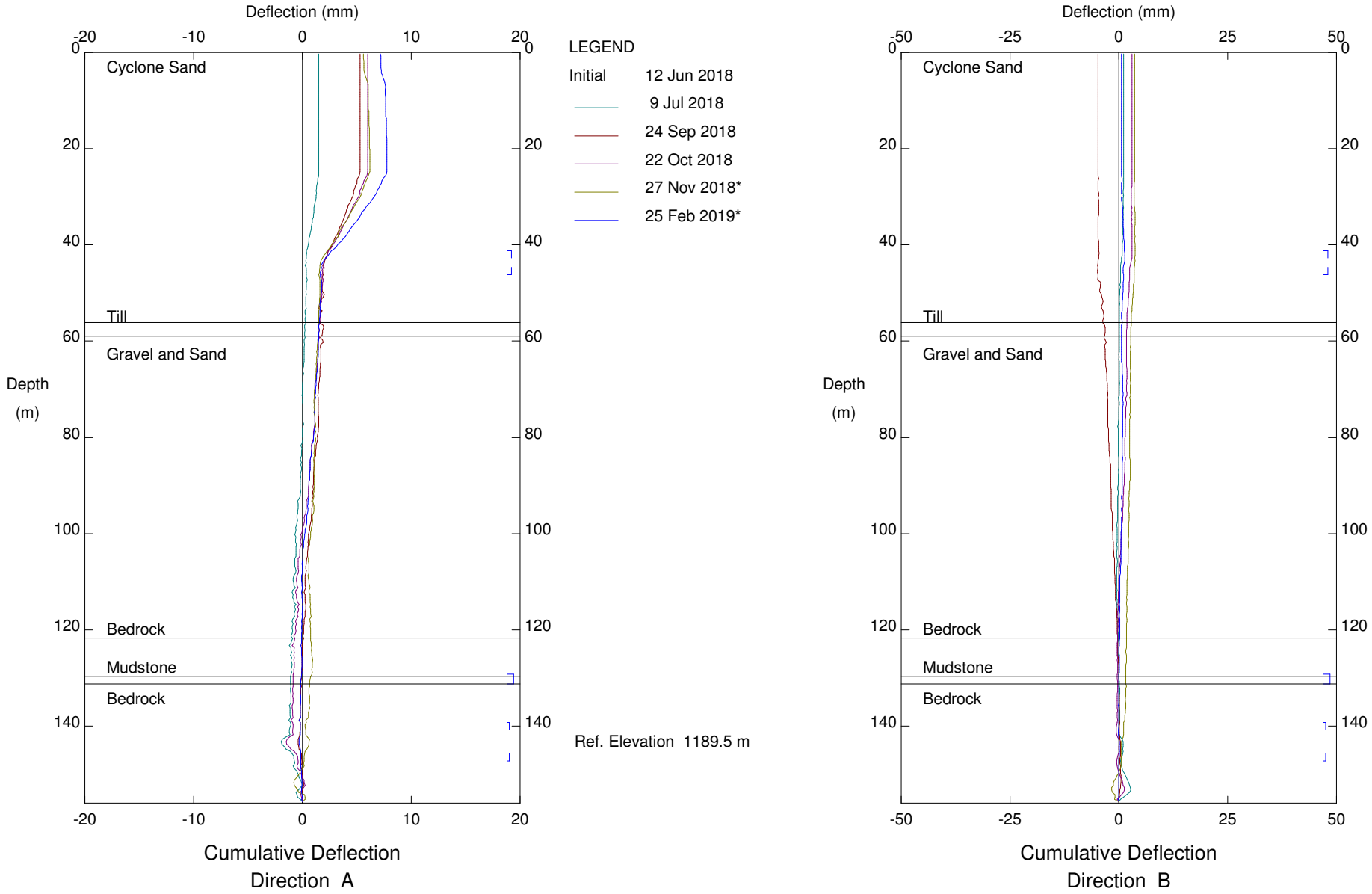
Borehole : I10-5
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1189.50 meters

Spiral Correction : N/A
Movement Depth : 41.5 - 46.5 meters
Reading Depth : 155.5 meters
A+ Groove Azimuth :
Latest Reading : 2019 Jan 28 09:35
Initial Reading : 2017 Oct 09 18:03
Applied Azimuth : 0.0 degrees

Time Plot : 41.5 - 46.5 meters



Highland Valley Copper - Logan Lake, BC

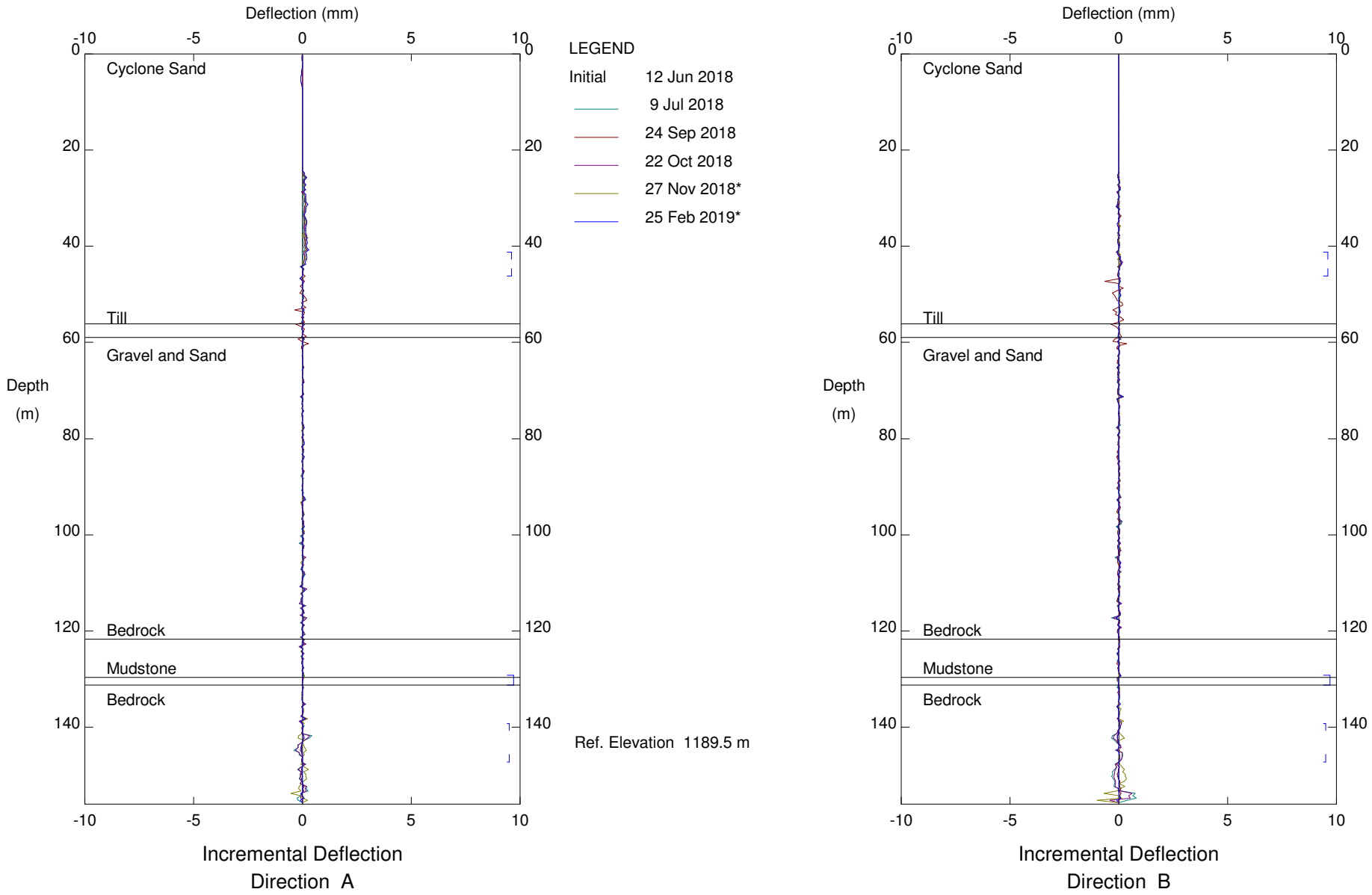


LL Dam, Inclinometer I10-5

Sets marked * include zero shift and/or rotation corrections.

V:\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\L-L Dam\SI Monitoring\Inclinalysis Files\1----Including dam fill\I10-5\GTILT\I10-5.gtl

Highland Valley Copper - Logan Lake, BC

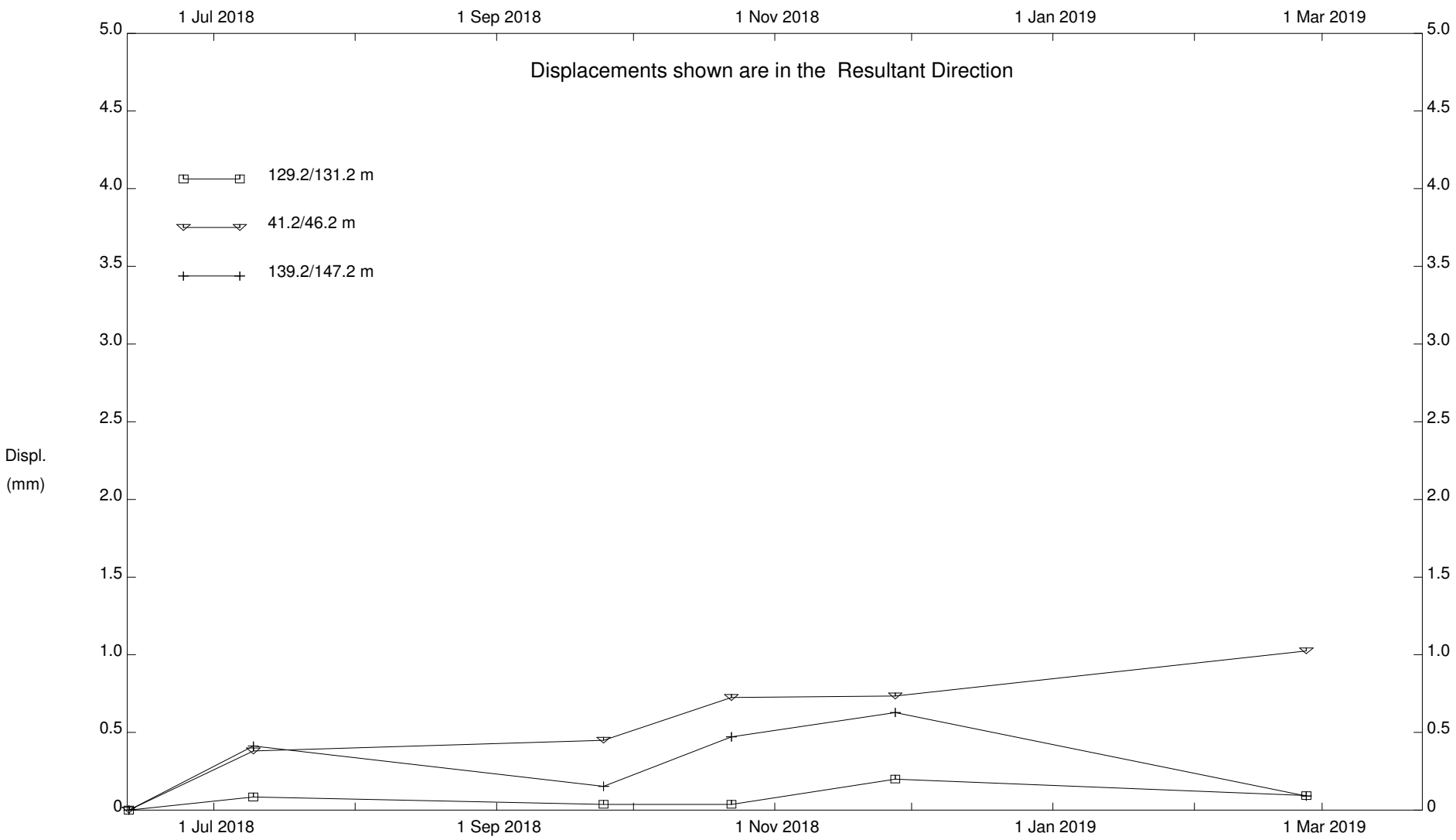


LL Dam, Inclinometer I10-5

Sets marked * include zero shift and/or rotation corrections.

V:\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\L-L Dam\SI Monitoring\Inclinalysis Files\1----Including dam fill\I10-5\GTILT\I10-5.gtl

Highland Valley Copper - Logan Lake, BC



LL Dam, Inclinometer I10-5

VALLEY BUTTRESS BERM EXTENSION

I10-11

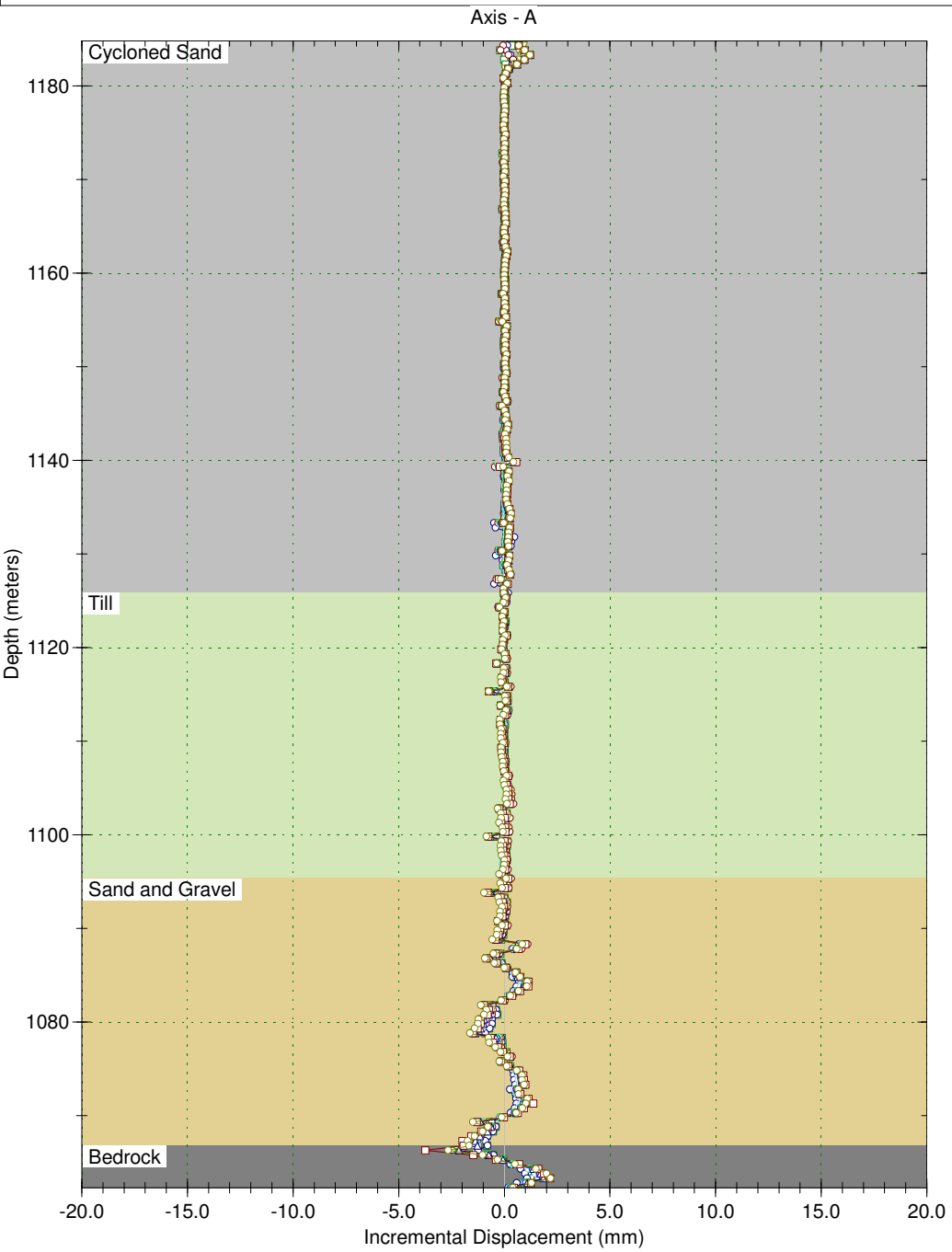
RST Instruments Ltd.

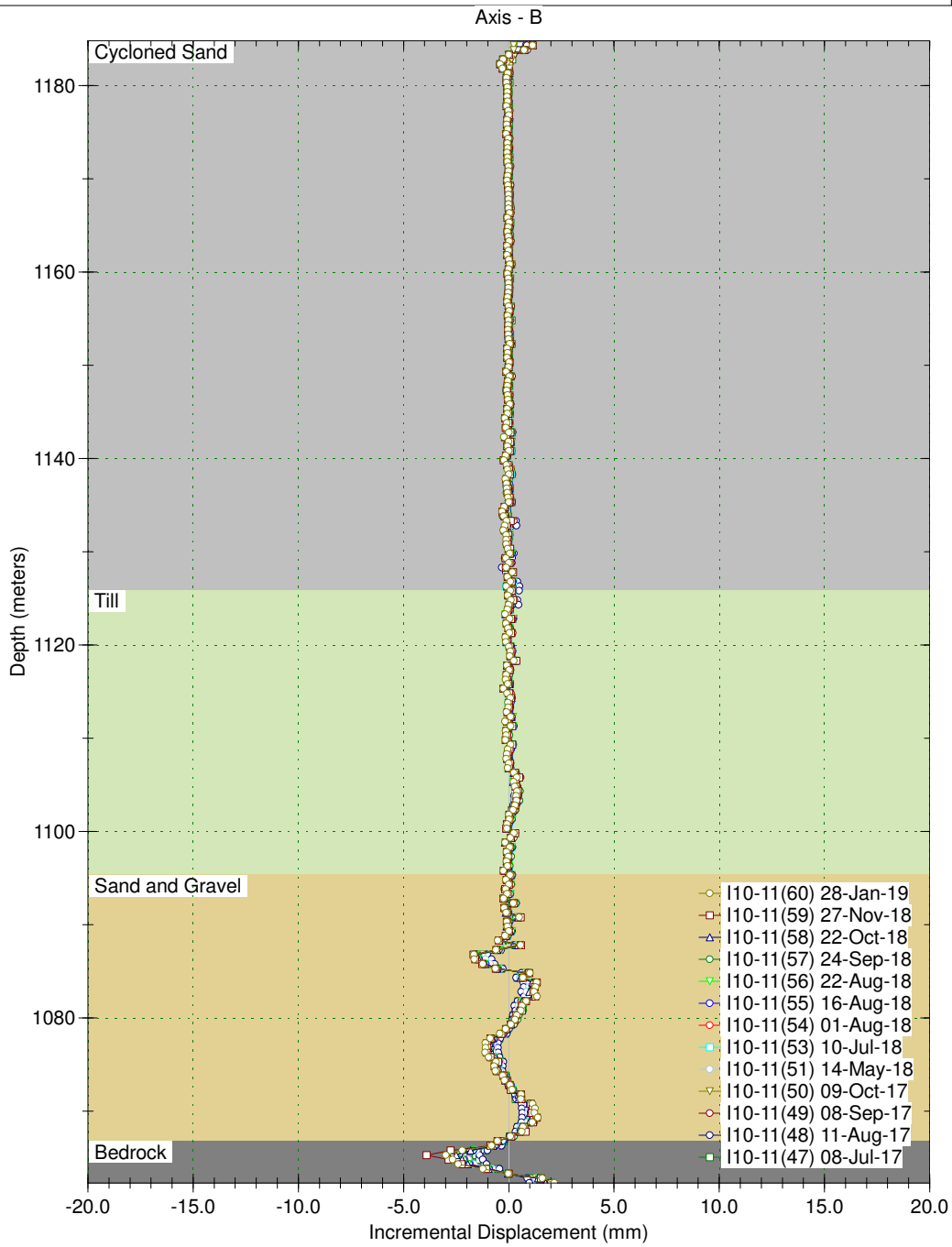
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I10-11
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : Enabled
Collar Elevation : :1184.80 meters
Reading Depth : 122.5 meters
A+ Groove Azimuth :
Base Reading : 2017 Jun 16 10:19
Applied Azimuth : 0.0 degrees





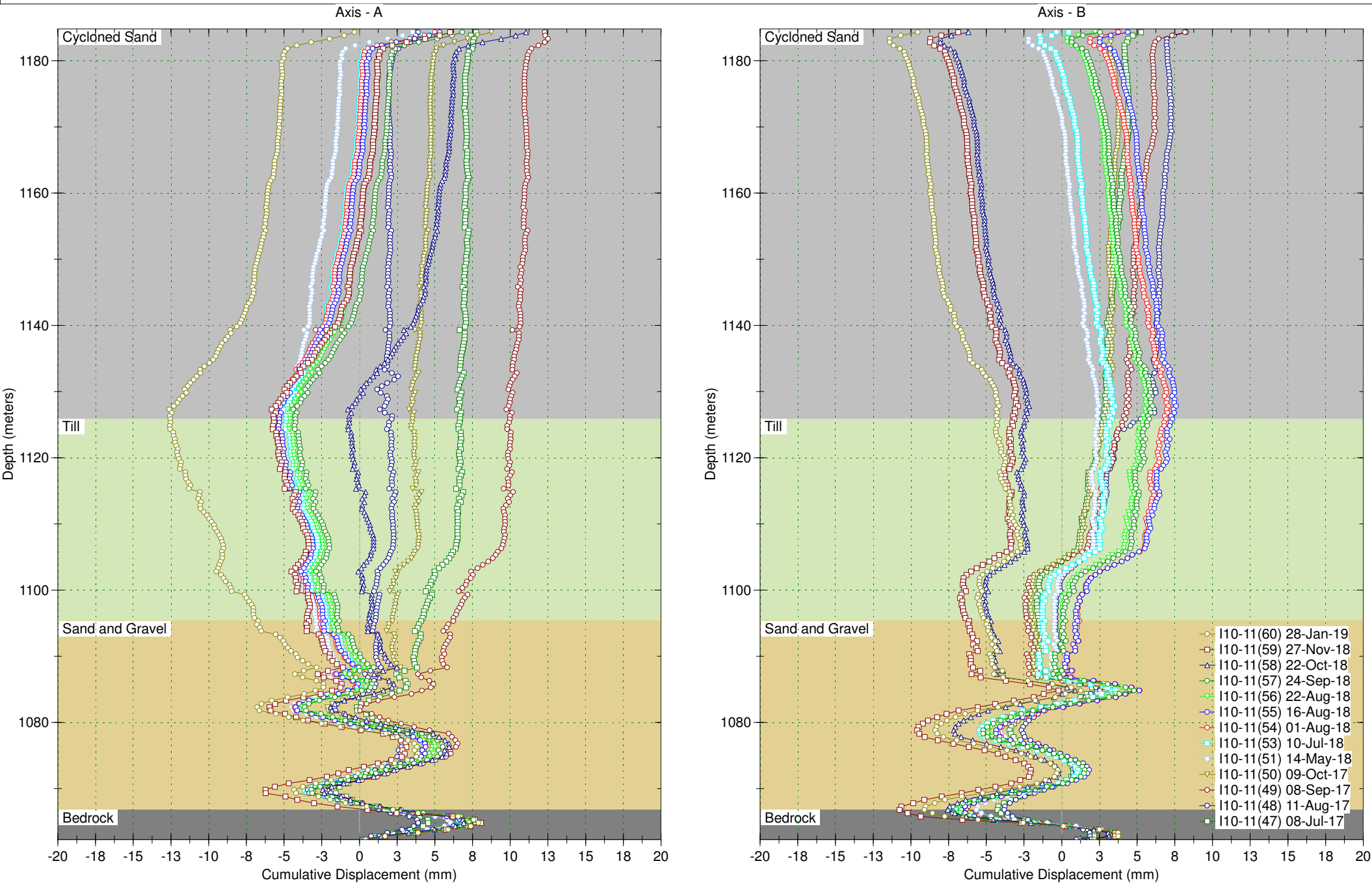
RST Instruments Ltd.

CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I10-11
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : Enabled
Collar Elevation : :1184.80 meters
Reading Depth : 122.5 meters
A+ Groove Azimuth :
Base Reading : 2017 Jun 16 10:19
Applied Azimuth : 0.0 degrees



VALLEY BUTTRESS BERM EXTENSION

I17-07

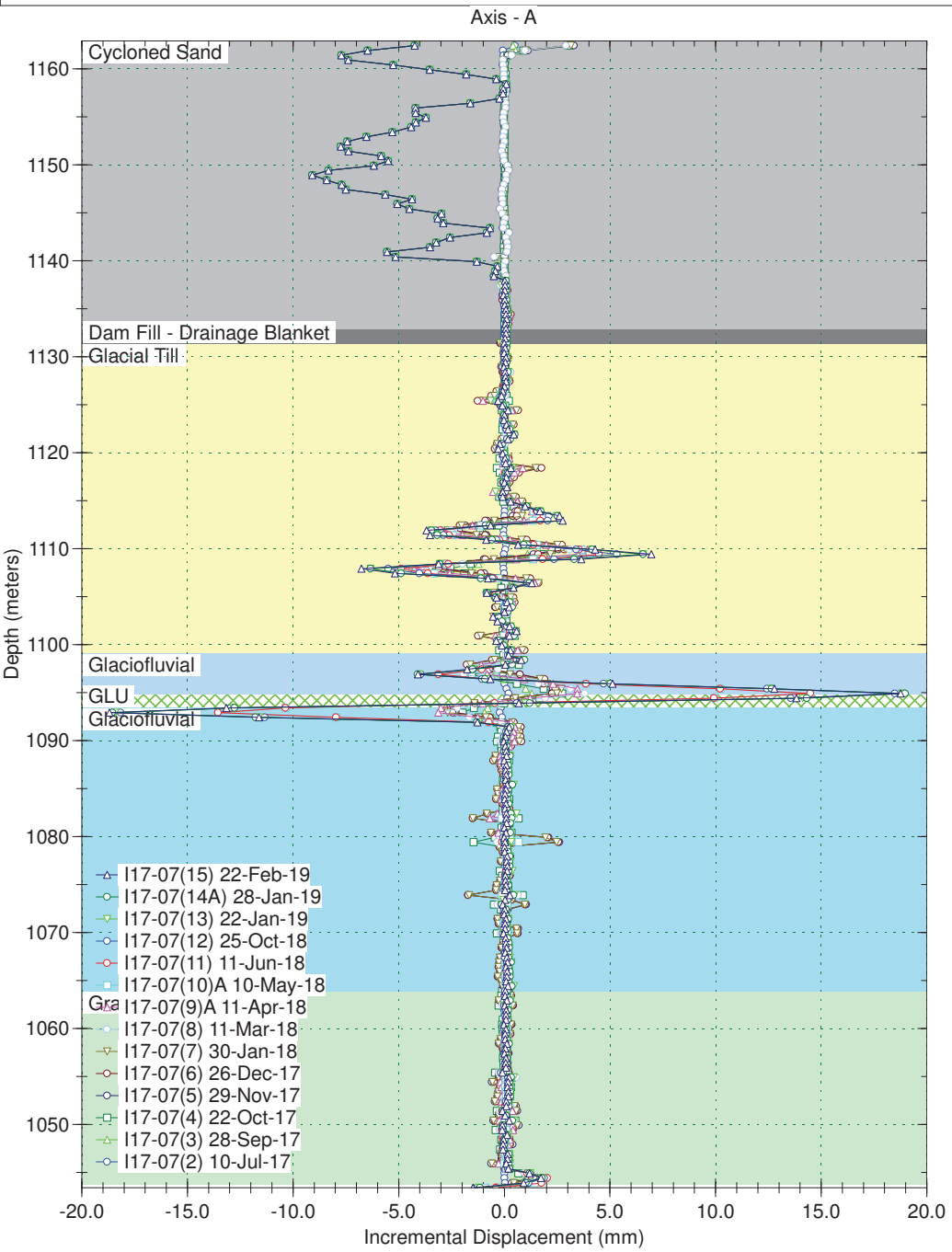
RST Instruments Ltd.

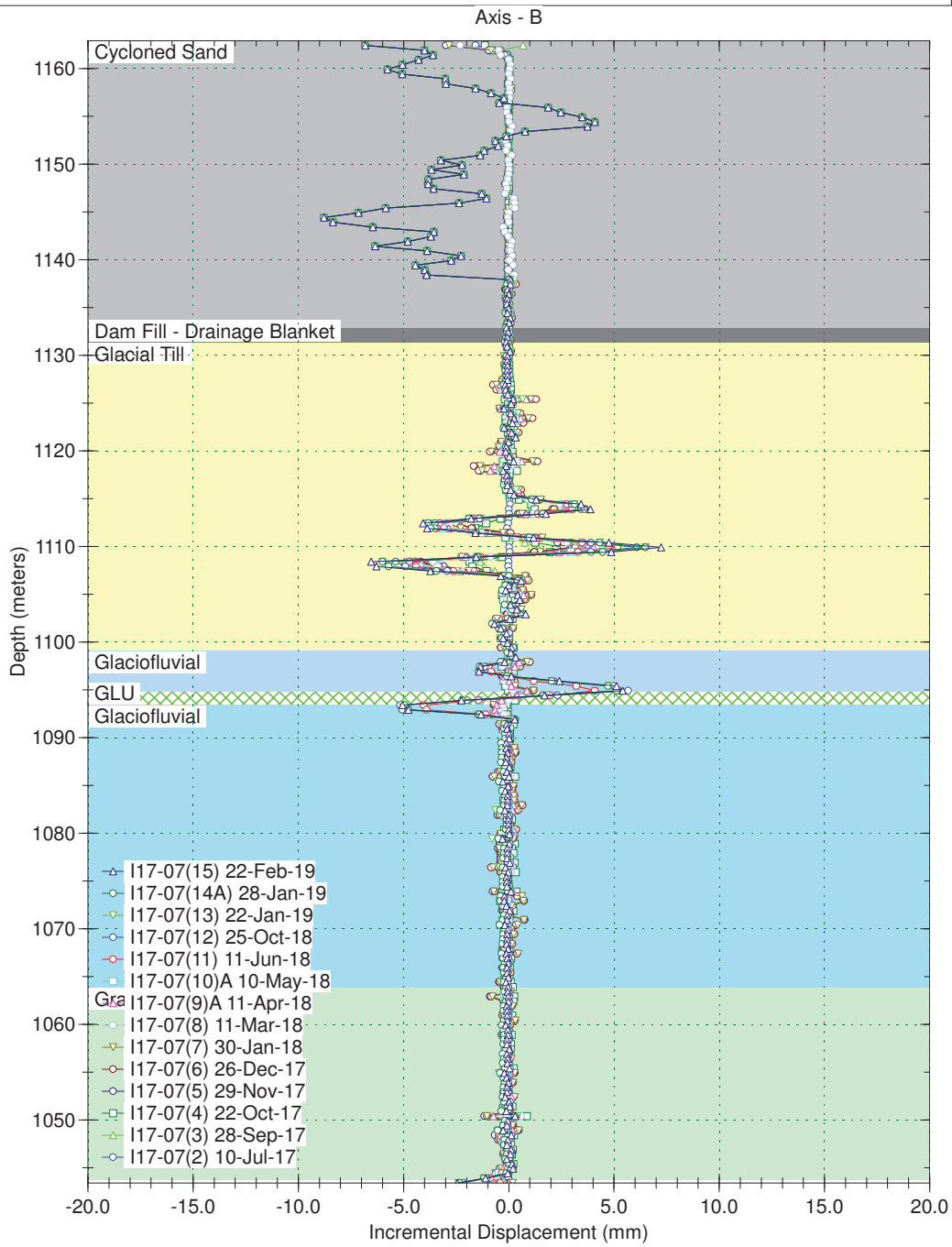
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-07
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1162.90 meters
Reading Depth : 119.5 meters
A+ Groove Azimuth :
Base Reading : 2017 Jul 10 14:56
Applied Azimuth : 0.0 degrees





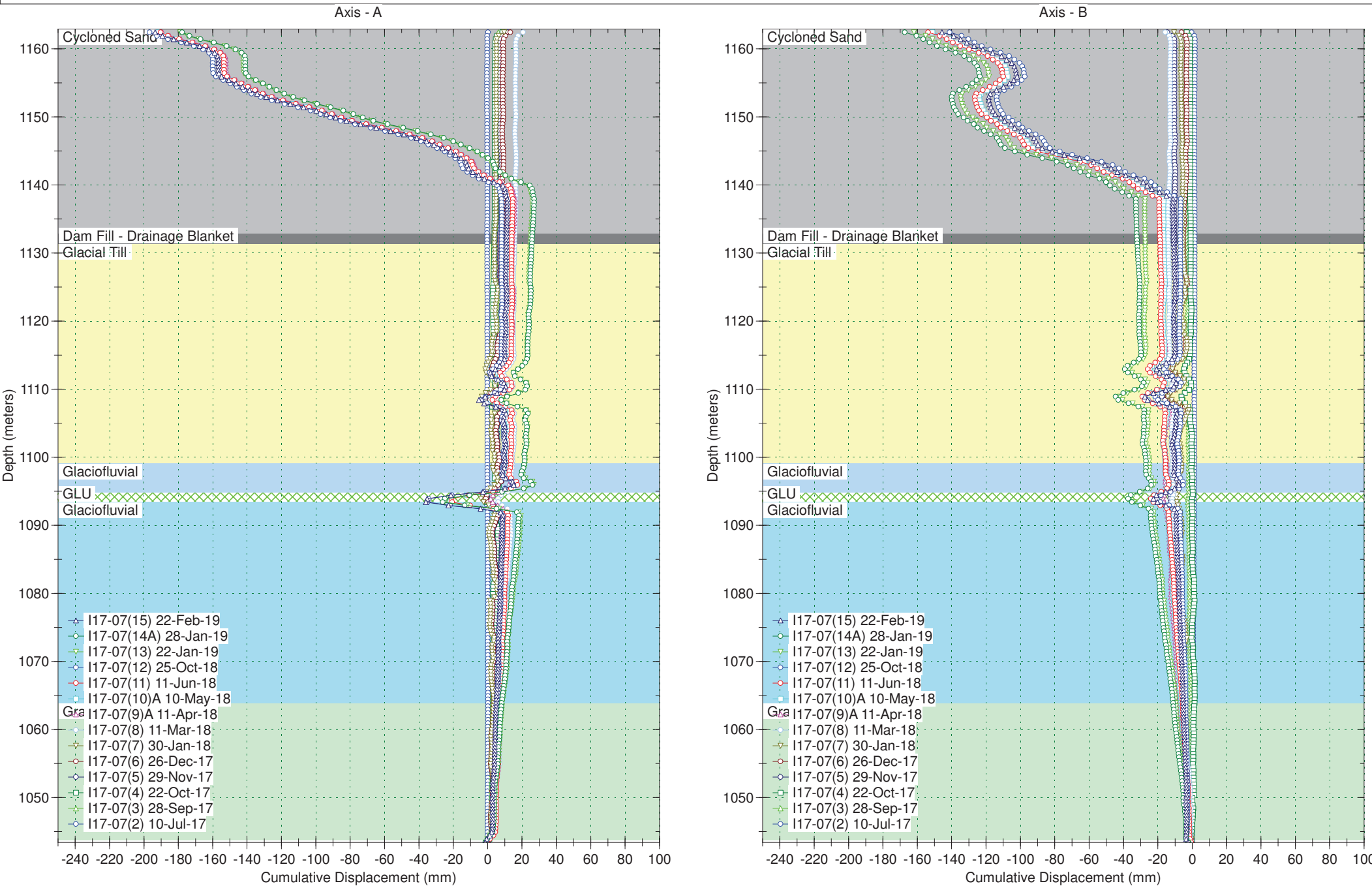
RST Instruments Ltd.

CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-07
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1162.90 meters
Reading Depth : 119.5 meters
A+ Groove Azimuth :
Base Reading : 2017 Jul 10 14:56
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

TIME PLOT

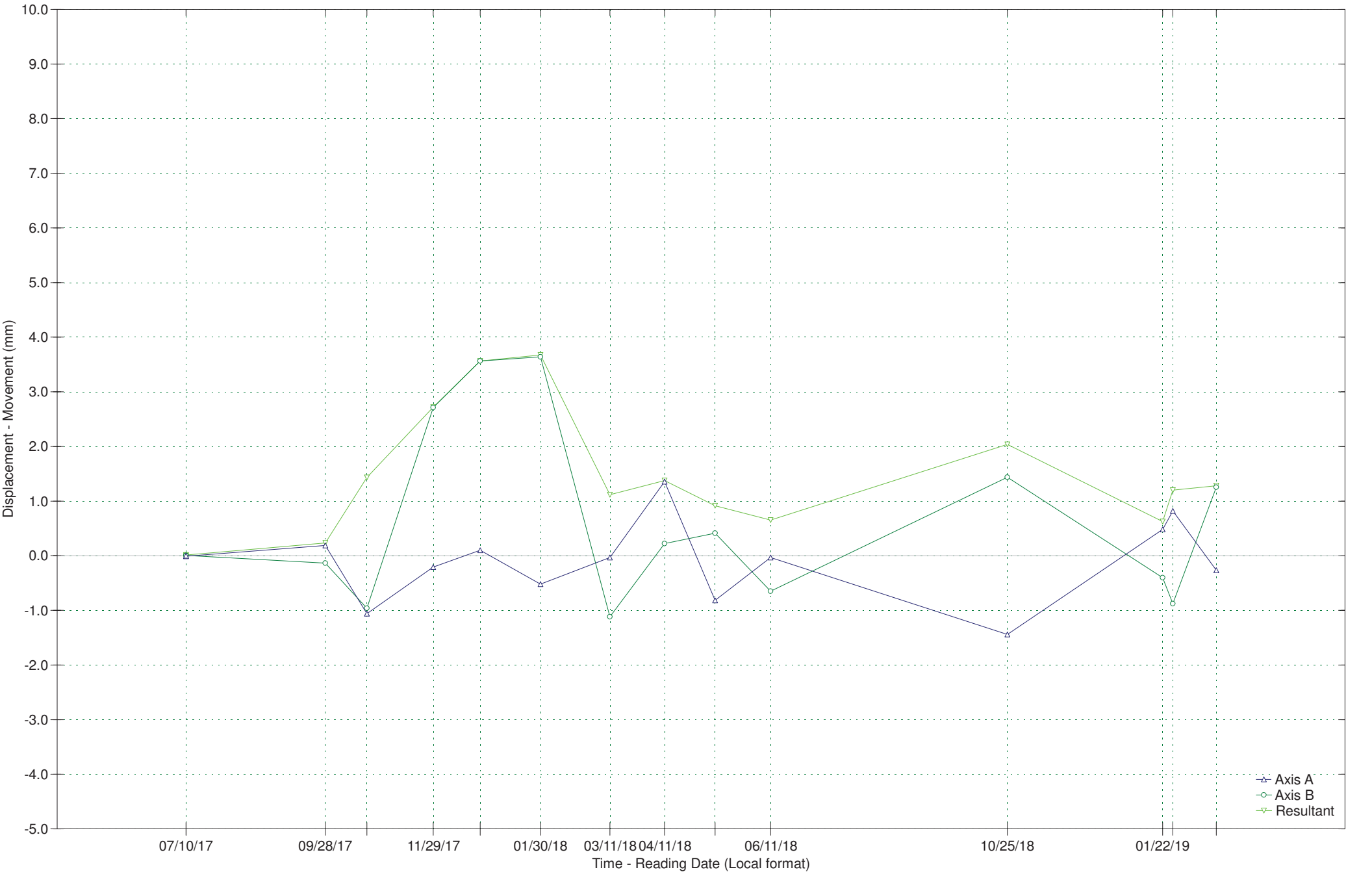
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-07
Location :
Northing :
Easting :
Collar :
Collar Elev : 1162.90 meters

Spiral Correction : N/A
Movement Depth : 48.0 - 60.0 meters
Reading Depth : 119.5 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 22 09:41
Initial Reading : 2017 Jul 10 14:56
Applied Azimuth : 0.0 degrees

Time Plot : 48.0 - 60.0 meters



RST Instruments Ltd.

TIME PLOT

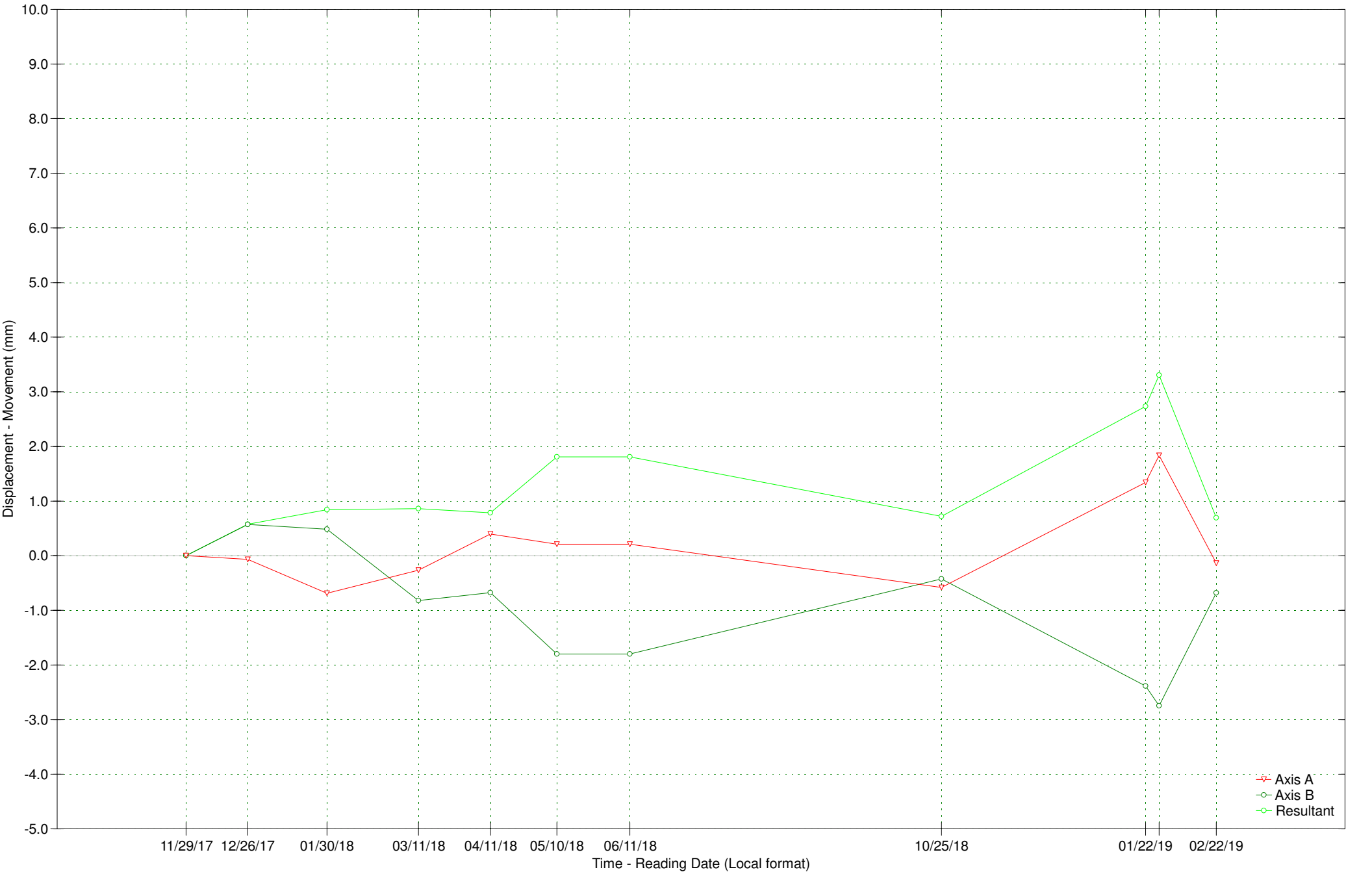
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I17-07
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1162.90 meters

Spiral Correction : N/A
Movement Depth : 64.0 - 72.0 meters
Reading Depth : 119.5 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 22 09:41
Initial Reading : 2017 Nov 29 15:18
Applied Azimuth : 0.0 degrees

Time Plot : 64.0 - 72.0 meters



VALLEY BUTTRESS BERM EXTENSION

I17-08

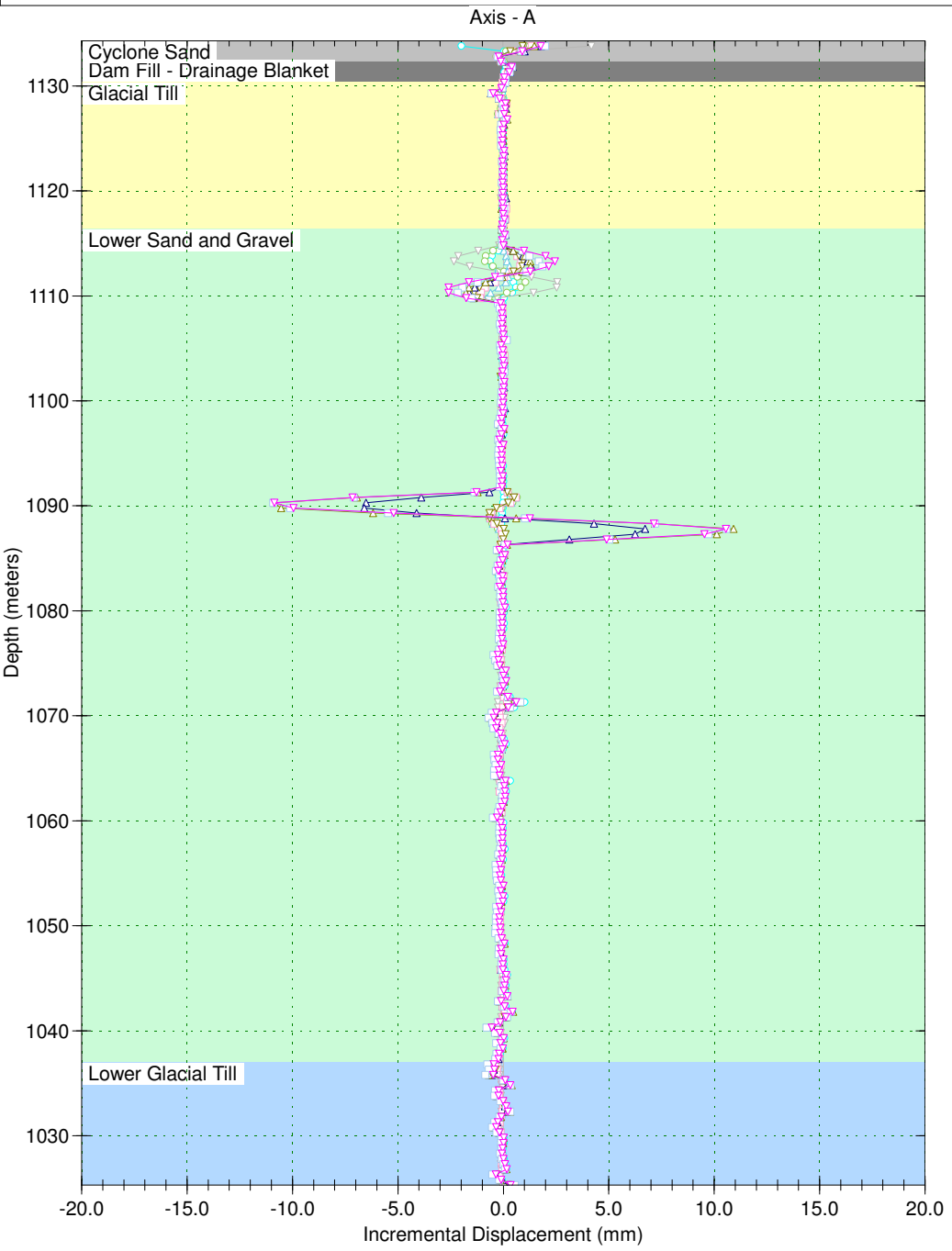
RST Instruments Ltd.

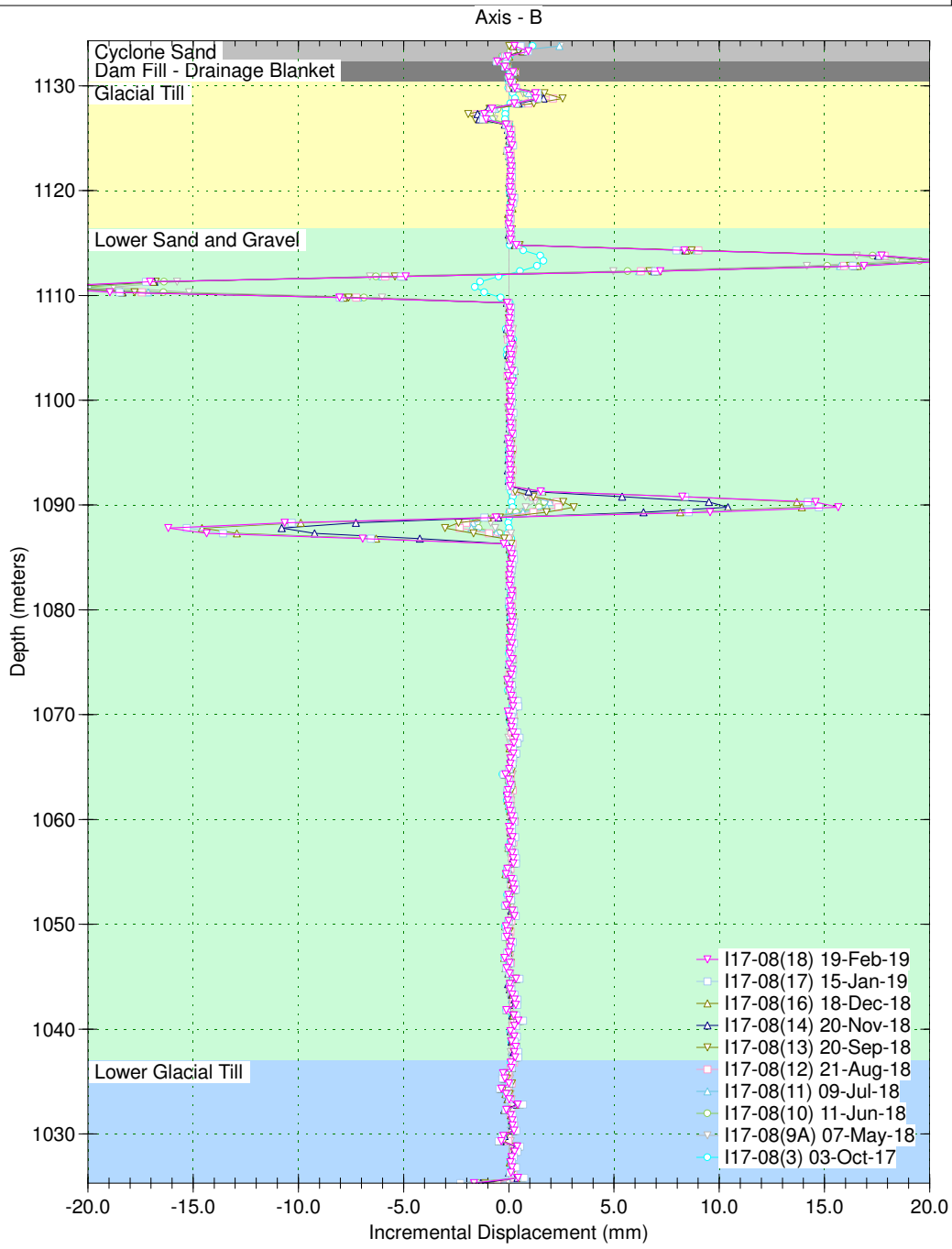
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I17-08
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1134.30 meters
Reading Depth : 109.0 meters
A+ Groove Azimuth :
Base Reading :
Applied Azimuth : 0.0 degrees





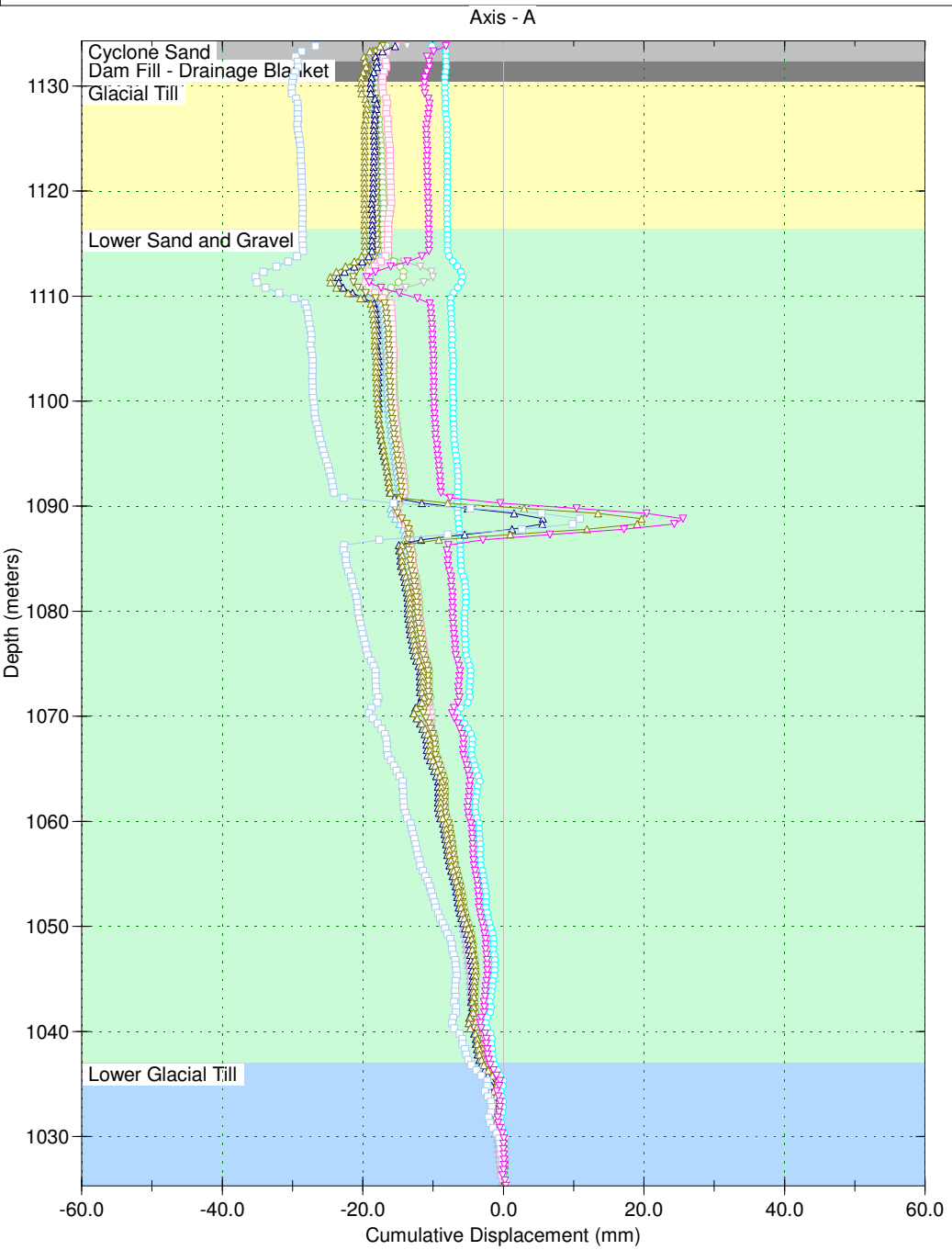
RST Instruments Ltd.

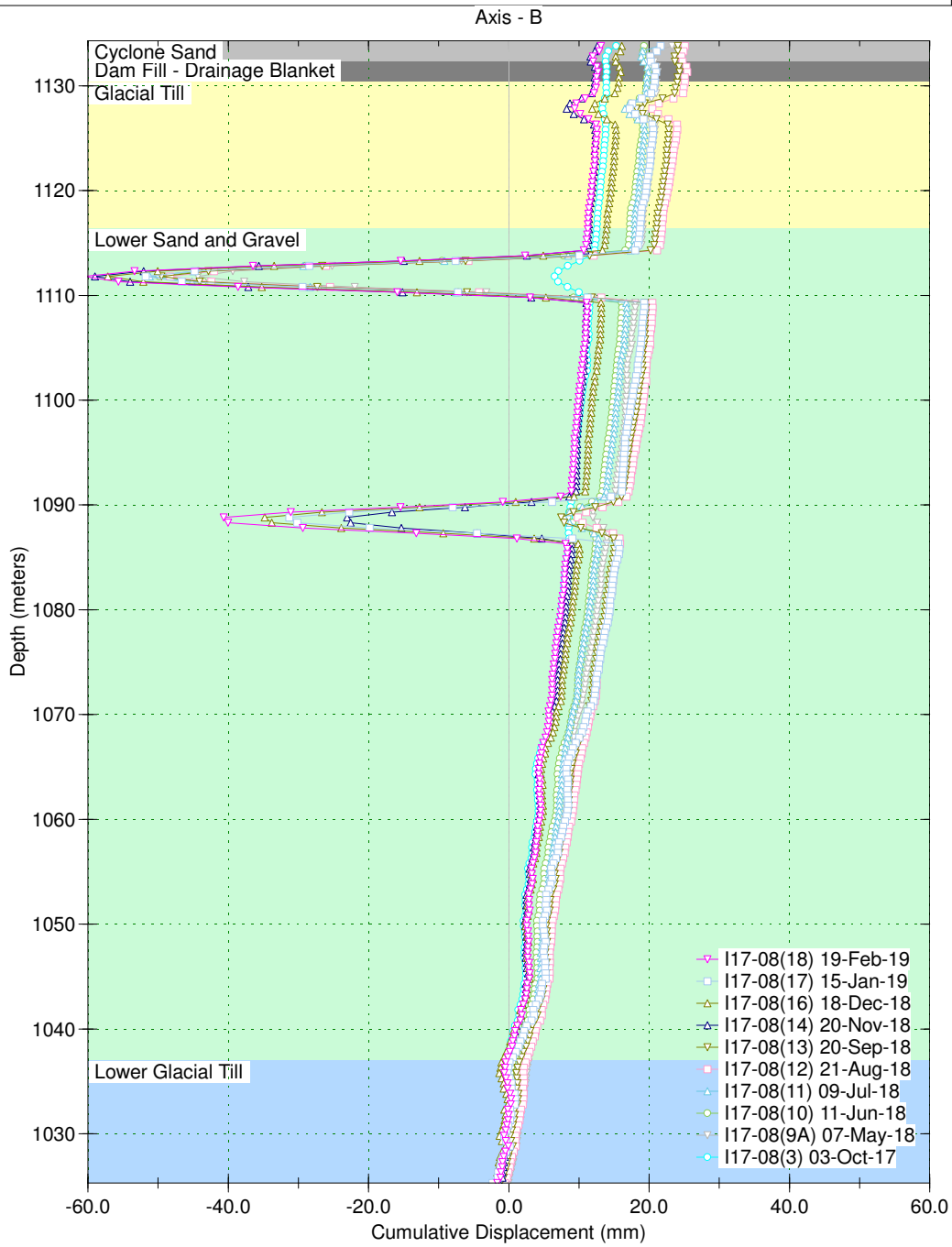
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I17-08
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1134.30 meters
Reading Depth : 109.0 meters
A+ Groove Azimuth :
Base Reading :
Applied Azimuth : 0.0 degrees





RST Instruments Ltd.

TIME PLOT

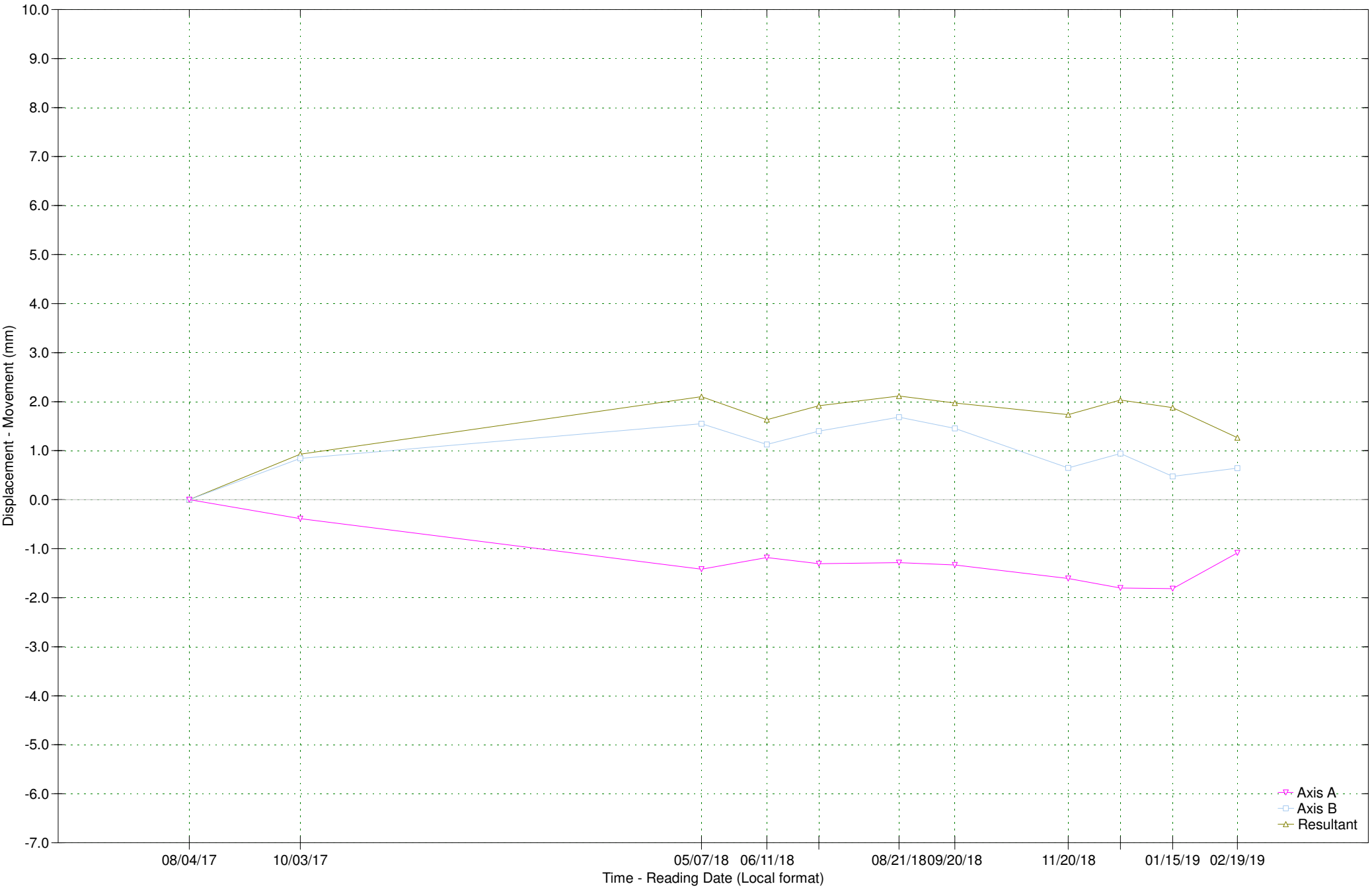
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I17-08
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1134.30 meters

Spiral Correction : N/A
Movement Depth : 42.5 - 48.5 meters
Reading Depth : 109.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 19 10:42
Initial Reading : 2017 Aug 04 21:26
Applied Azimuth : 0.0 degrees

Time Plot : 42.5 - 48.5 meters



RST Instruments Ltd.

TIME PLOT

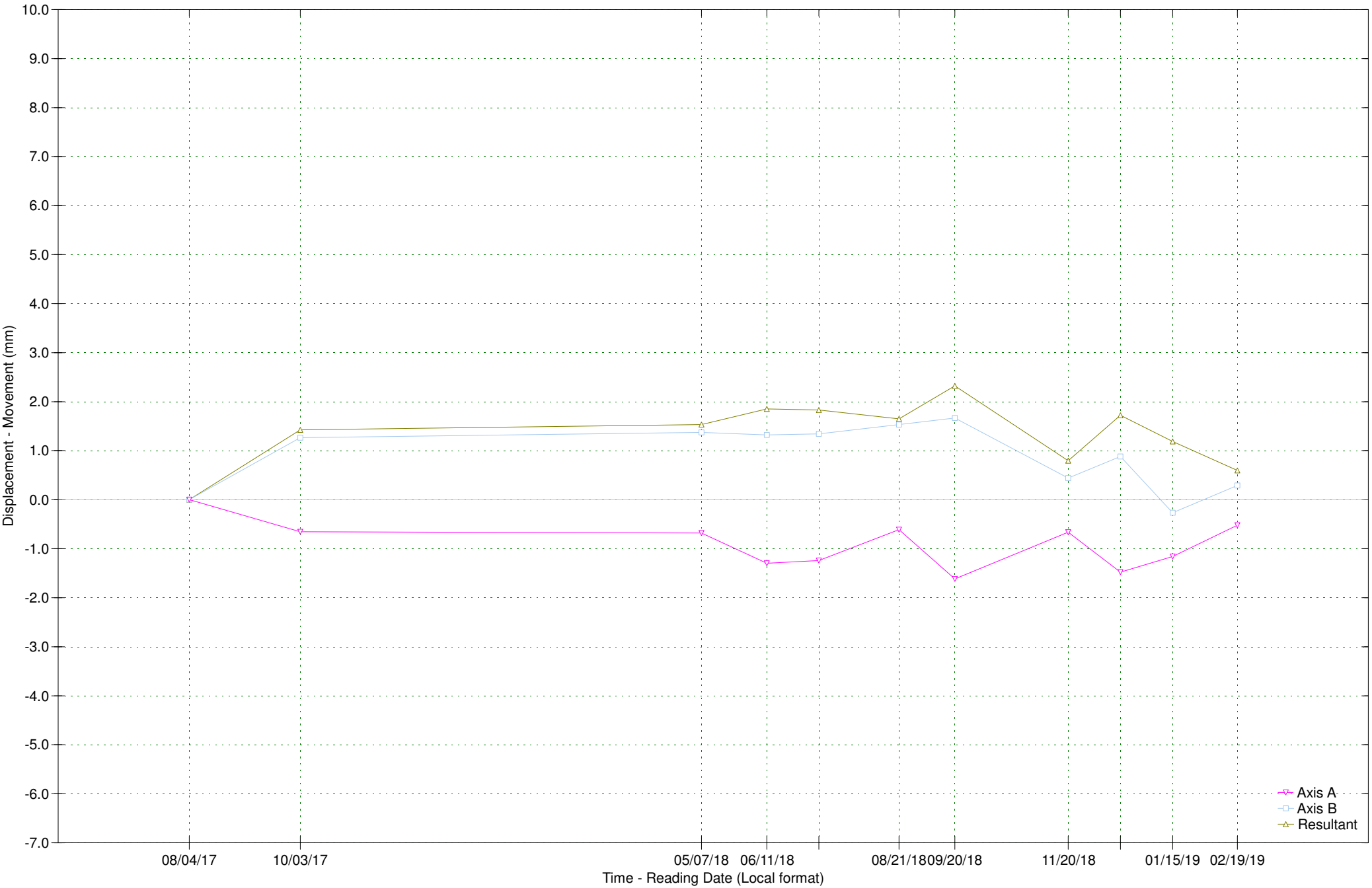
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I17-08
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1134.30 meters

Spiral Correction : N/A
Movement Depth : 18.0 - 27.0 meters
Reading Depth : 109.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 19 10:42
Initial Reading : 2017 Aug 04 21:26
Applied Azimuth : 0.0 degrees

Time Plot : 18.0 - 27.0 meters



VALLEY BUTTRESS BERM

I10-06

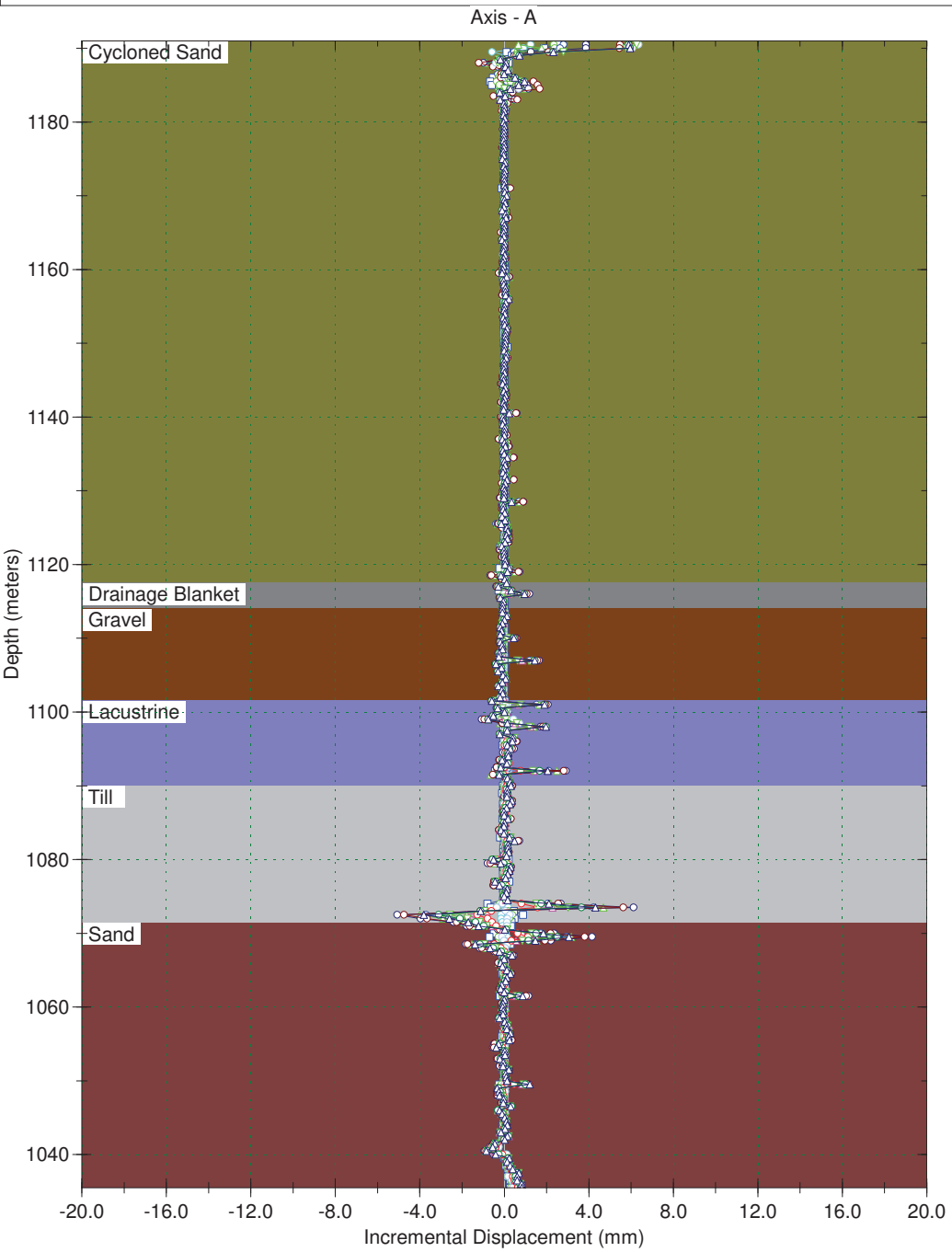
RST Instruments Ltd.

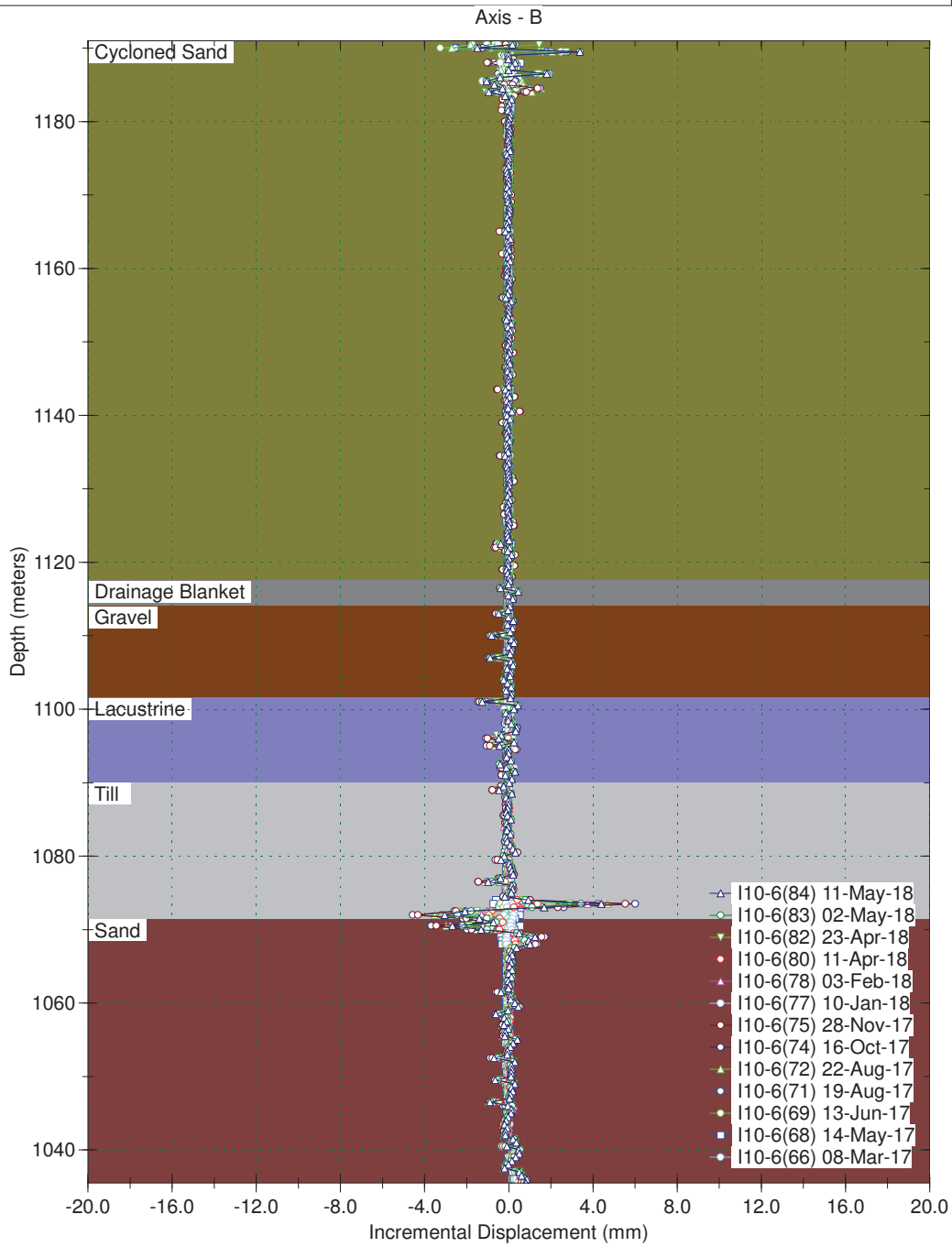
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I10-6
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1191.00 meters
Reading Depth : 155.5 meters
A+ Groove Azimuth :
Base Reading : 2017 Feb 12 13:17
Applied Azimuth : 0.0 degrees





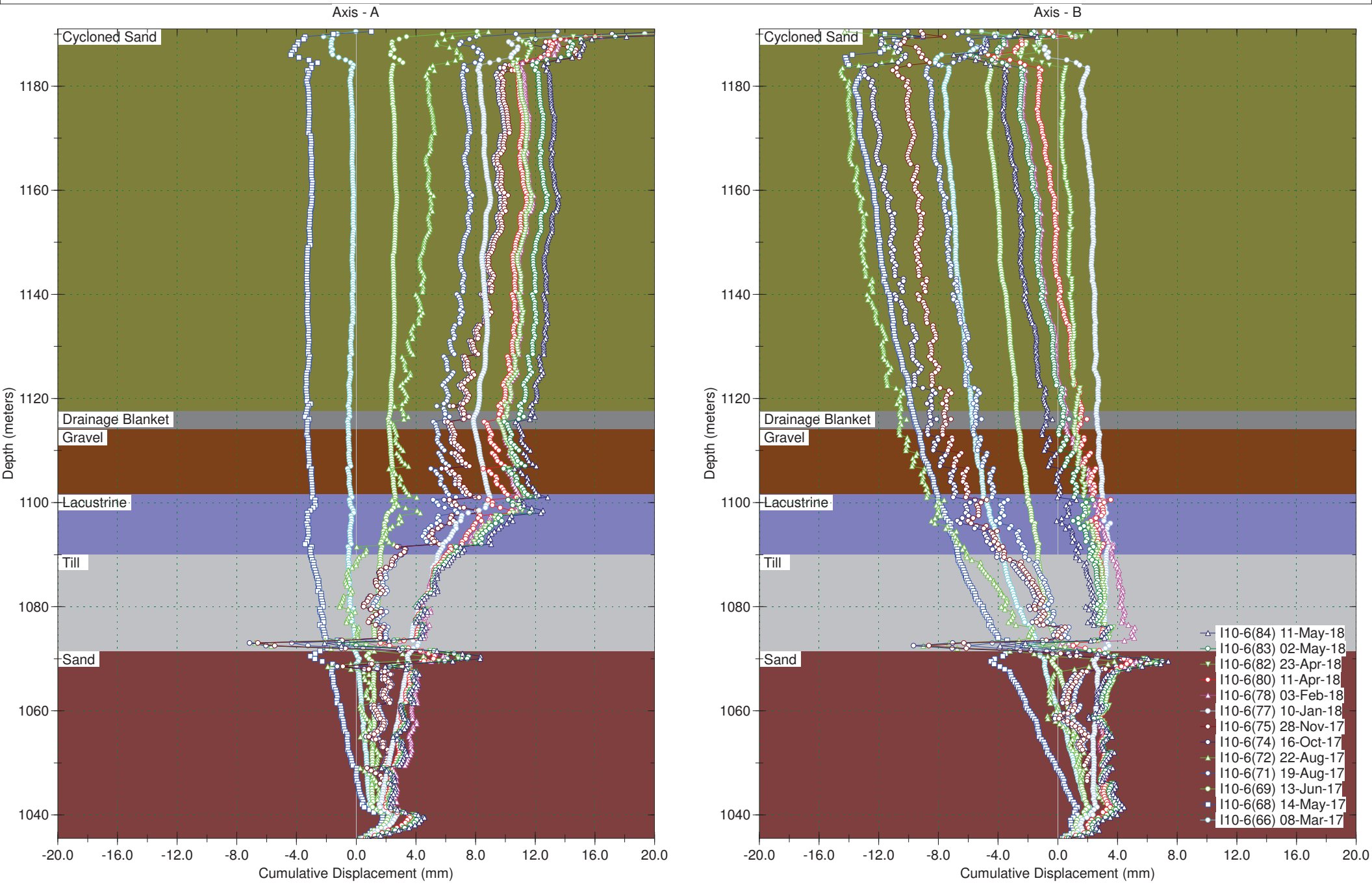
RST Instruments Ltd.

CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I10-6
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1191.00 meters
Reading Depth : 155.5 meters
A+ Groove Azimuth :
Base Reading : 2017 Feb 12 13:17
Applied Azimuth : 0.0 degrees



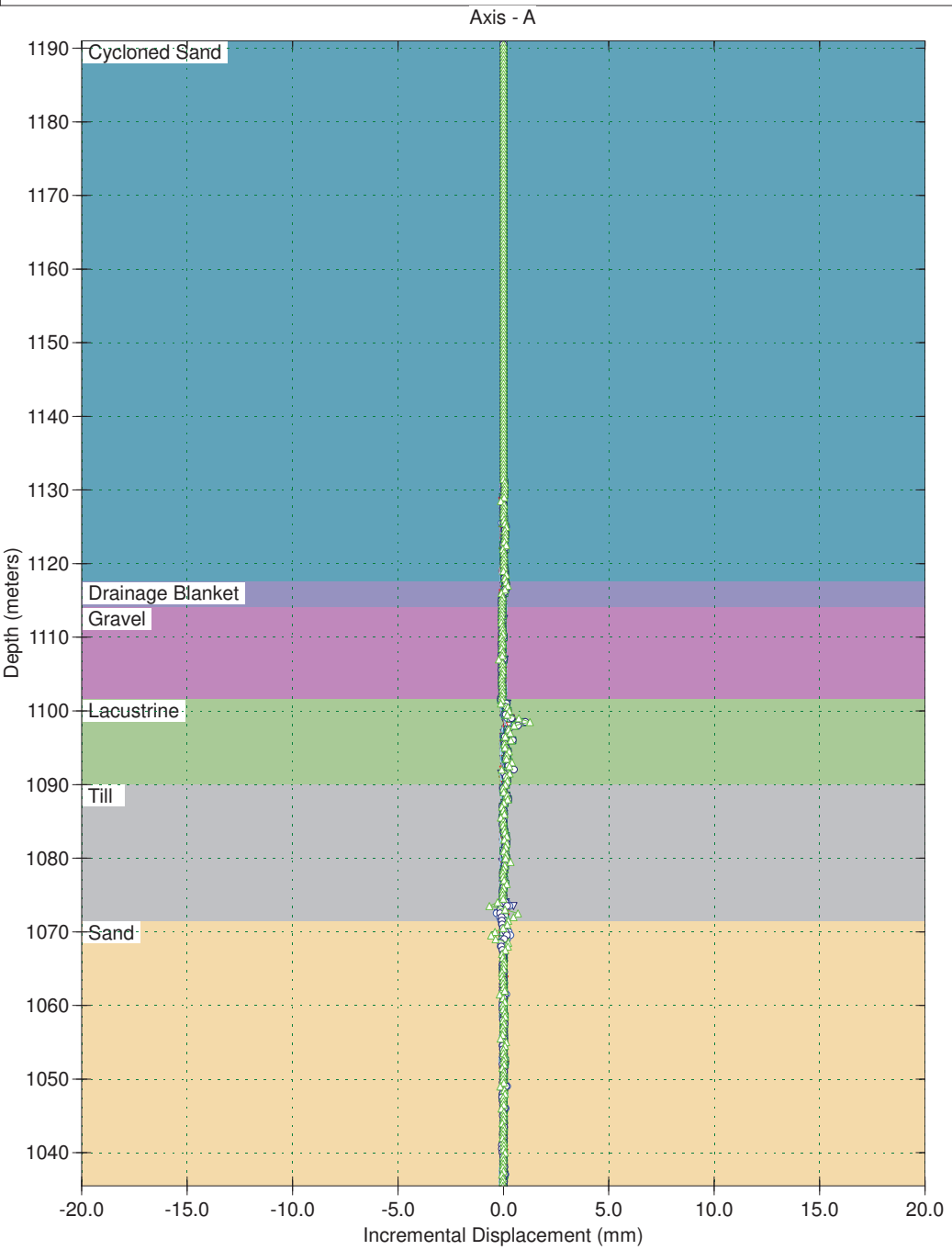
RST Instruments Ltd.

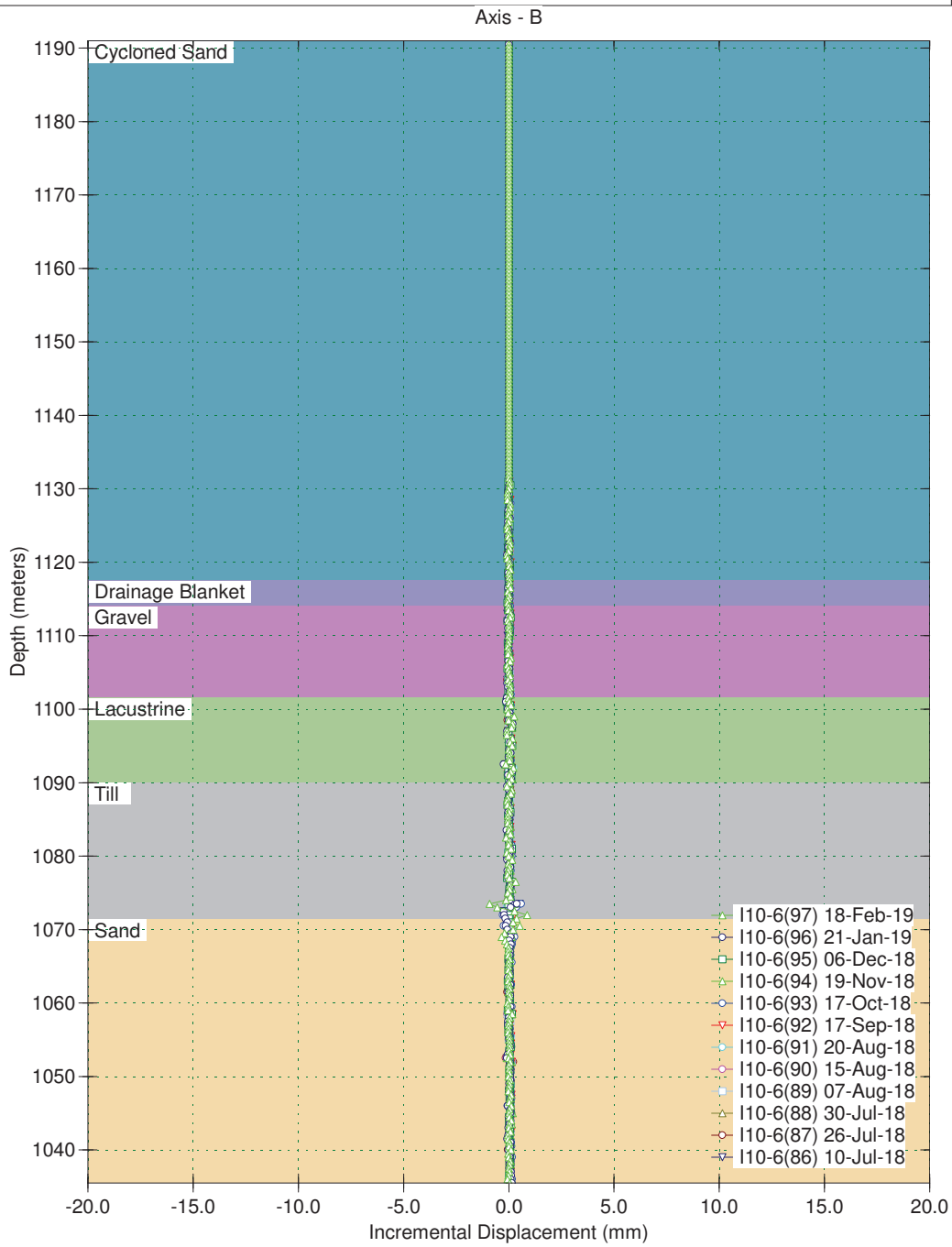
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I10-6
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : Enabled
Collar Elevation : :1191.00 meters
Reading Depth : 155.5 meters
A+ Groove Azimuth :
Base Reading : 2018 Jun 11 09:41
Applied Azimuth : 0.0 degrees





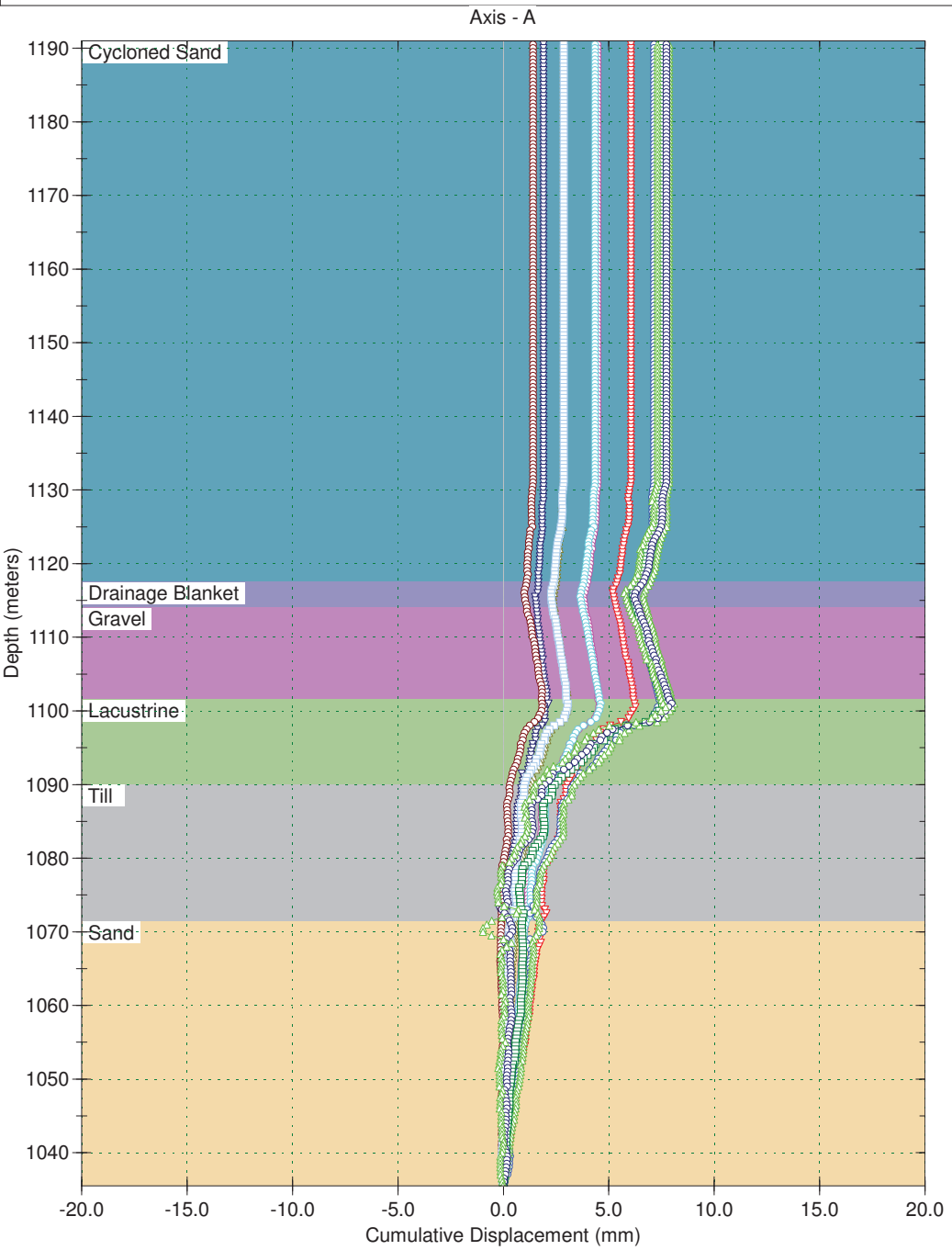
RST Instruments Ltd.

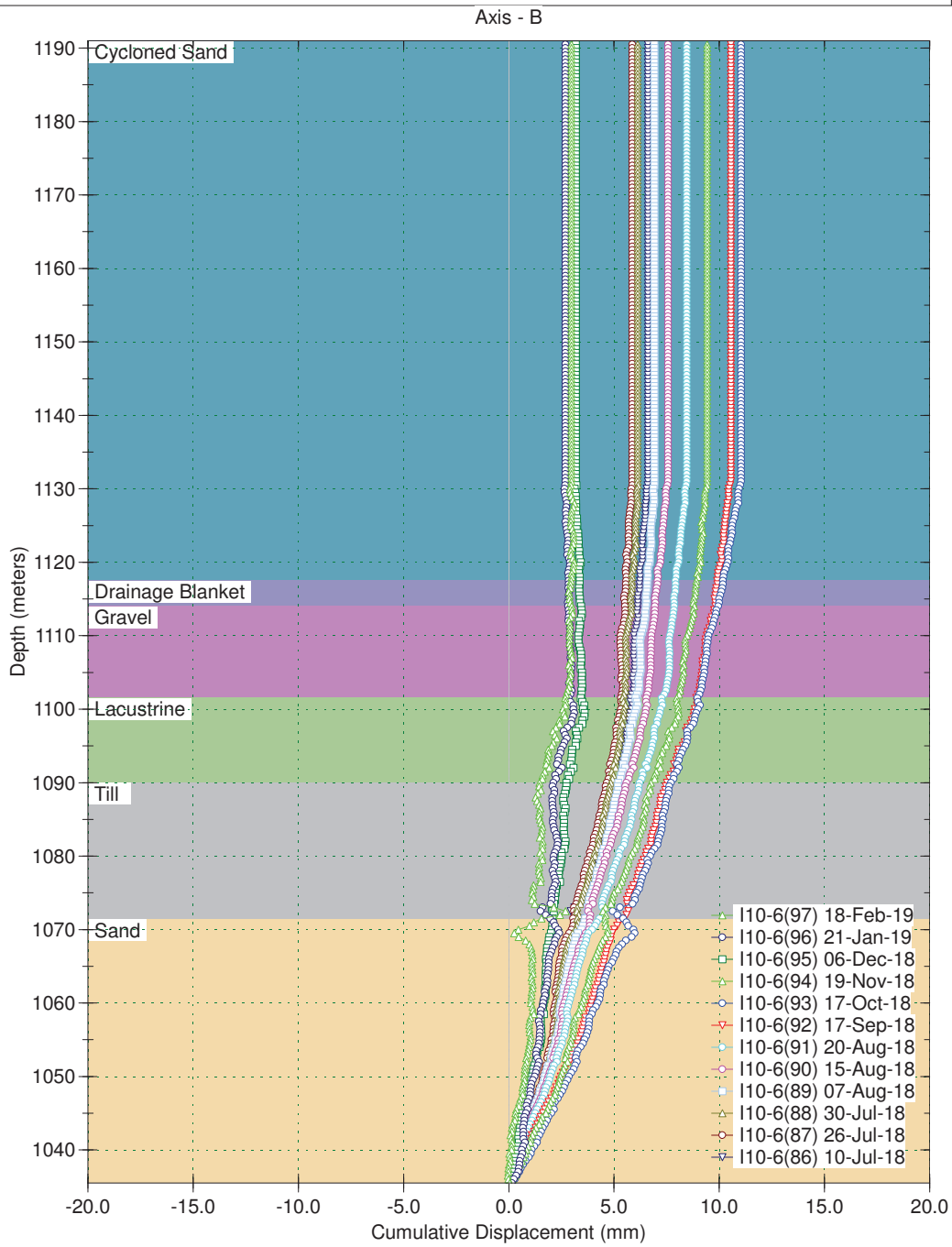
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I10-6
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : Enabled
Collar Elevation : :1191.00 meters
Reading Depth : 155.5 meters
A+ Groove Azimuth :
Base Reading : 2018 Jun 11 09:41
Applied Azimuth : 0.0 degrees





RST Instruments Ltd.

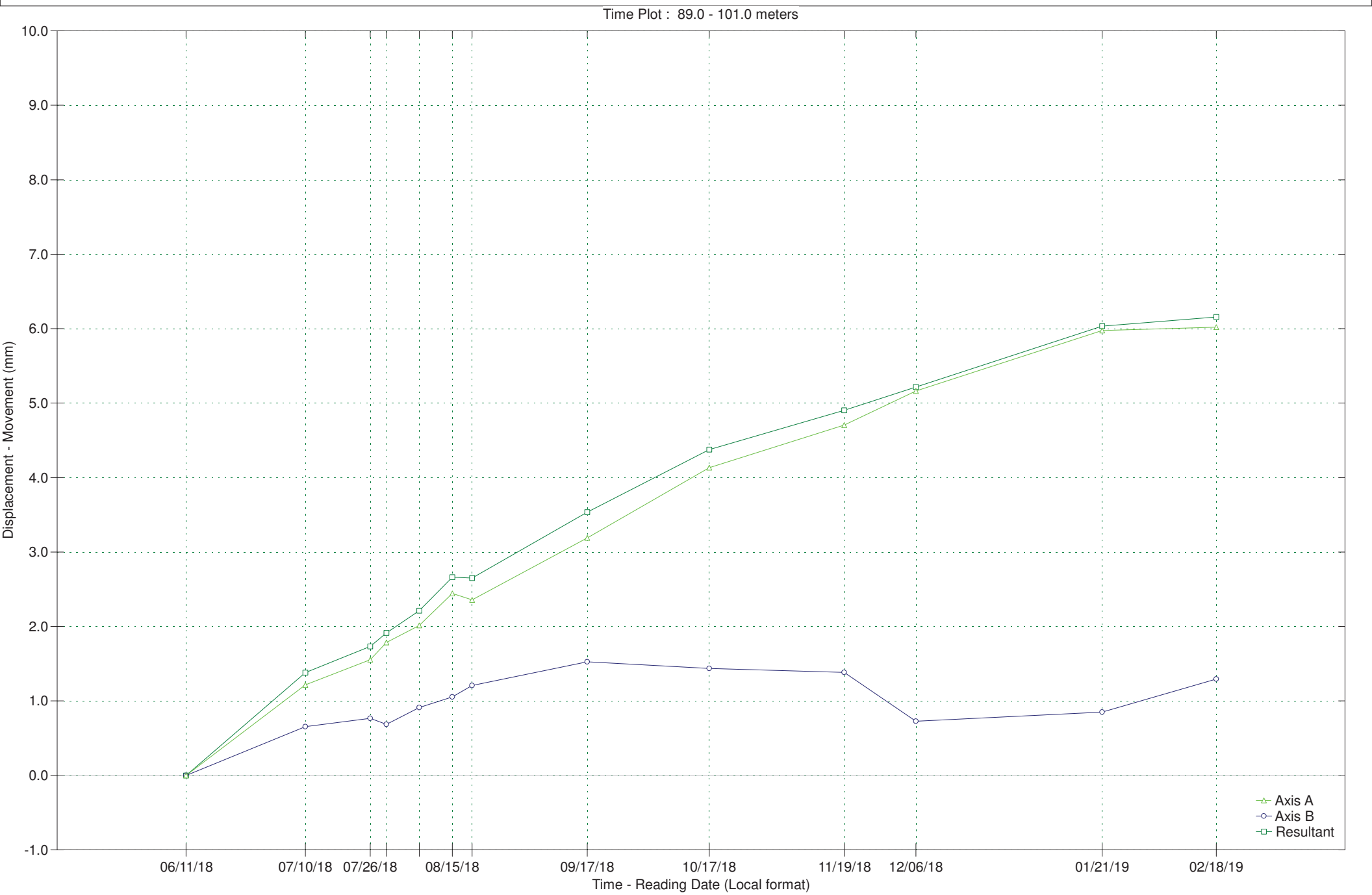
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I10-6
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1191.00 meters

Spiral Correction : Enabled
Movement Depth : 89.0 - 101.0 meters
Reading Depth : 155.5 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 18 11:35
Initial Reading : 2018 Jun 11 09:41
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

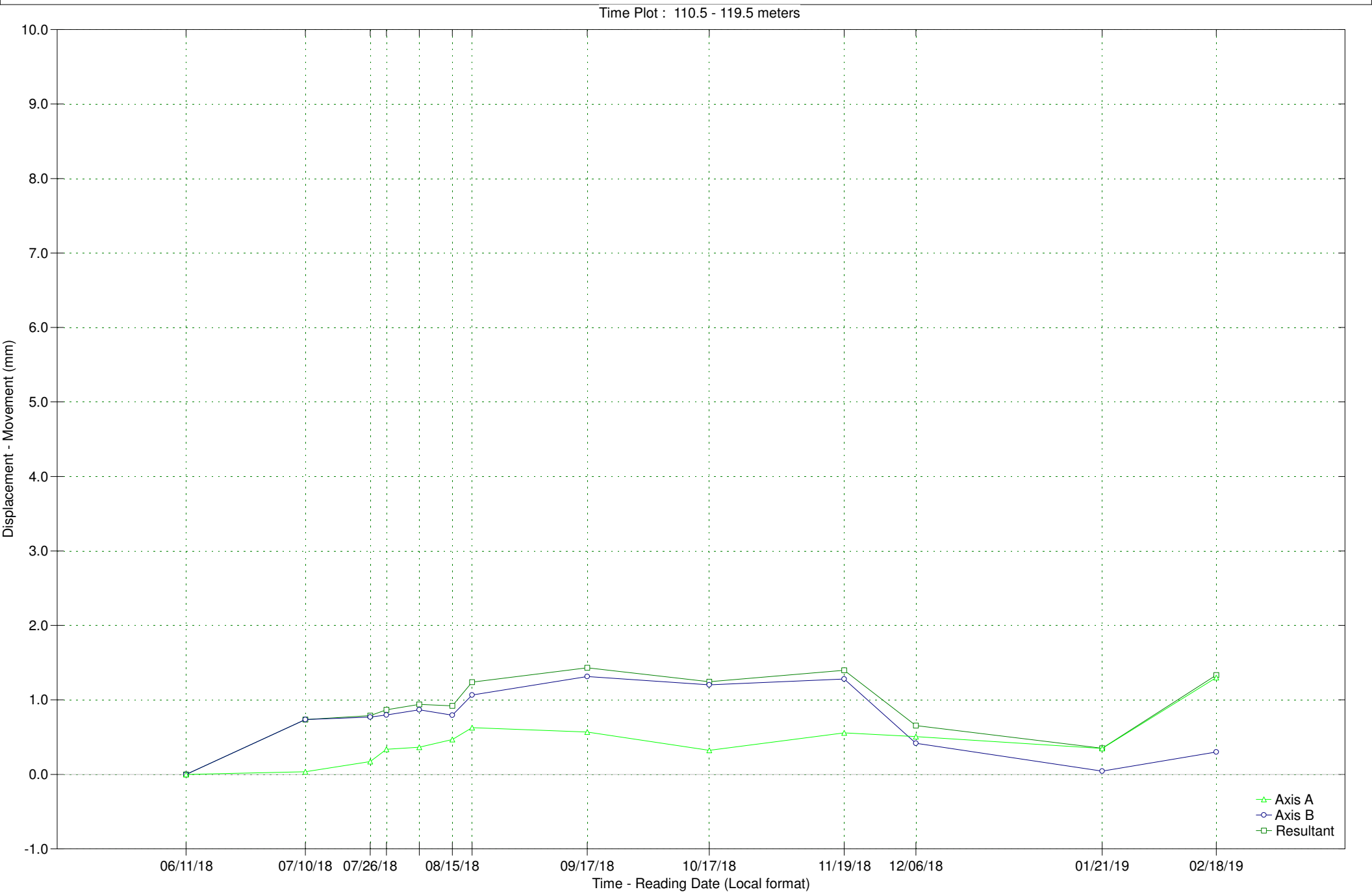
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I10-6
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1191.00 meters

Spiral Correction : Enabled
Movement Depth : 110.5 - 119.5 meters
Reading Depth : 155.5 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 18 11:35
Initial Reading : 2018 Jun 11 09:41
Applied Azimuth : 0.0 degrees



VALLEY BUTTRESS BERM

I10-07

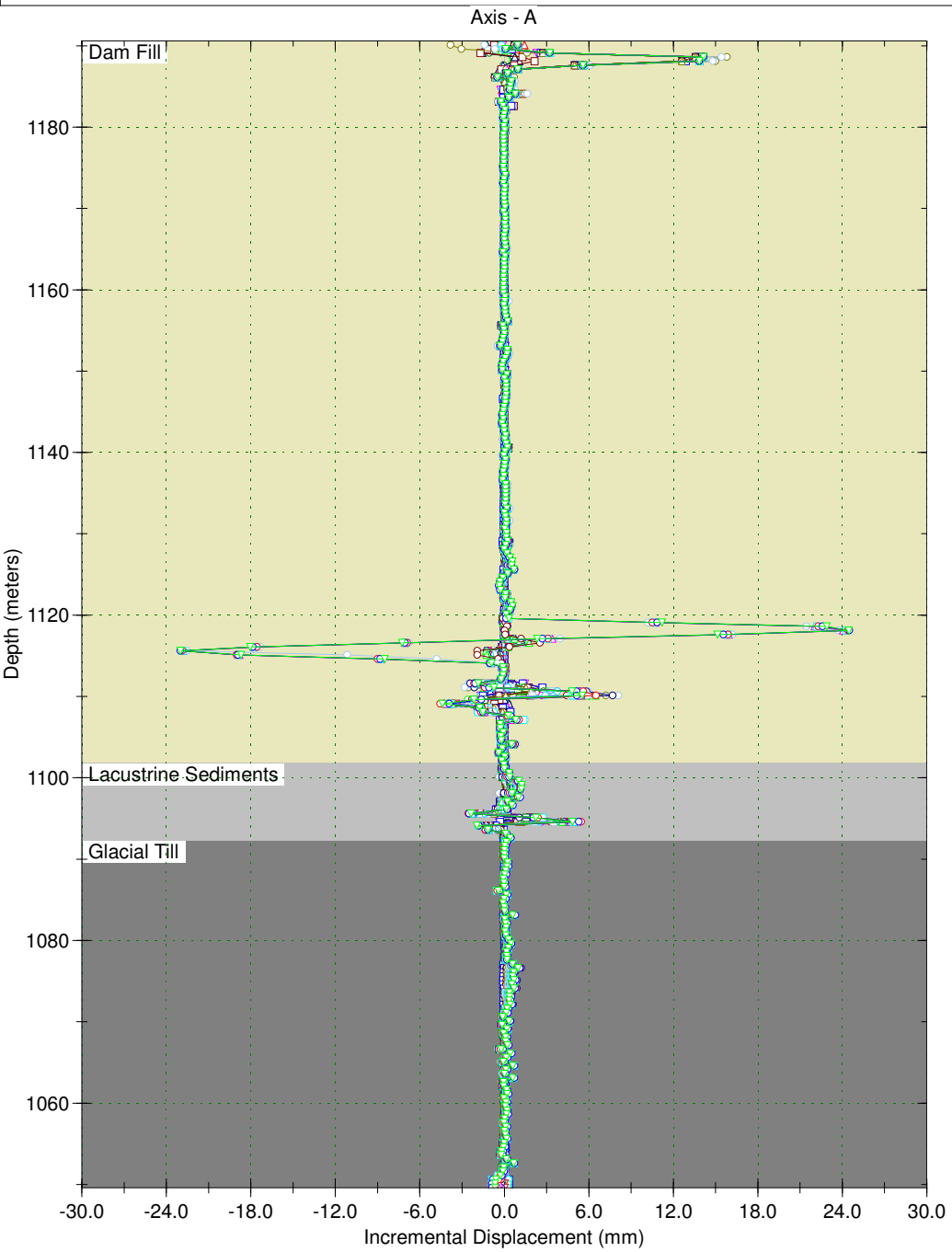
RST Instruments Ltd.

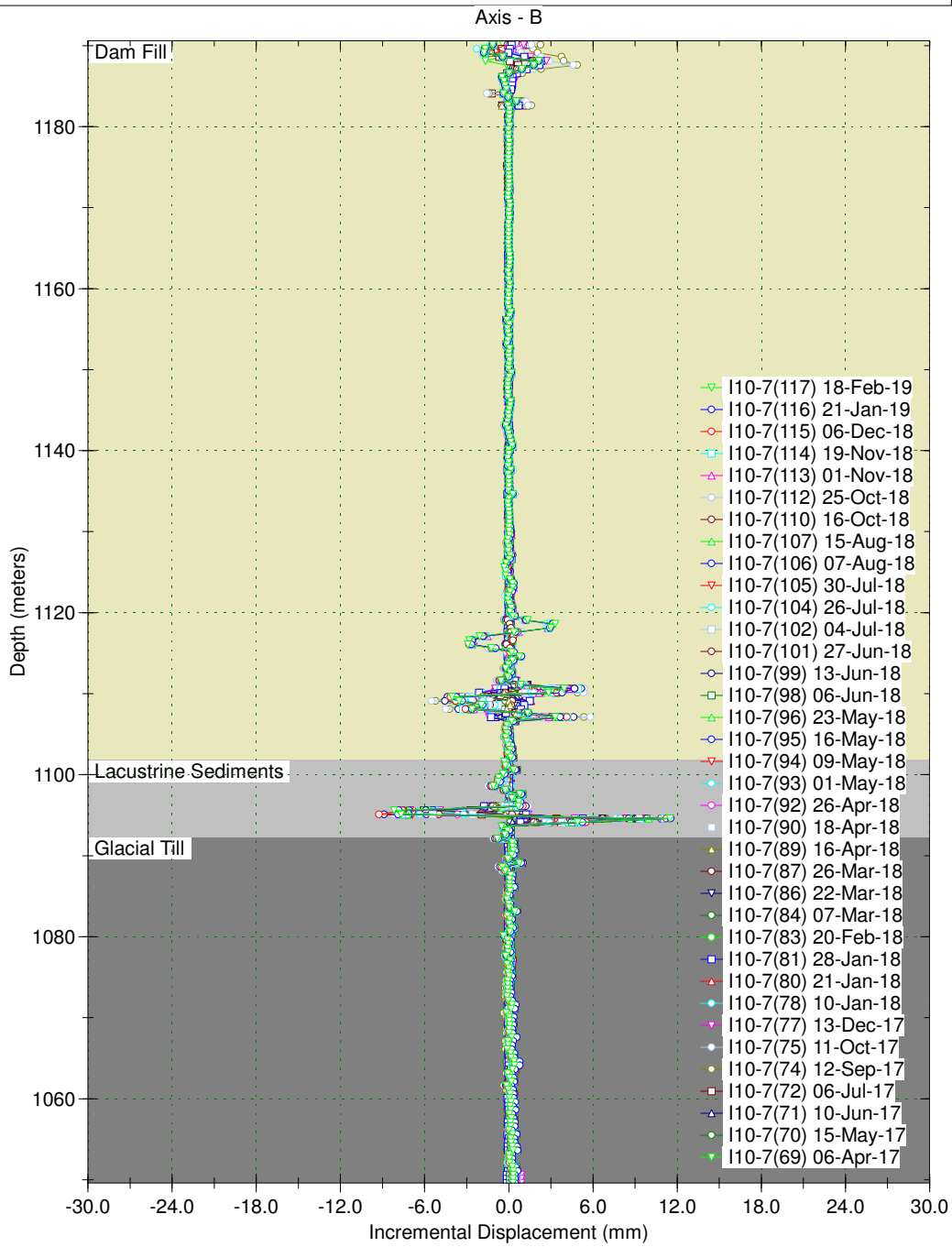
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I10-7
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1190.60 meters
Reading Depth : 141.0 meters
A+ Groove Azimuth :
Base Reading : 2017 Mar 10 21:34
Applied Azimuth : 0.0 degrees





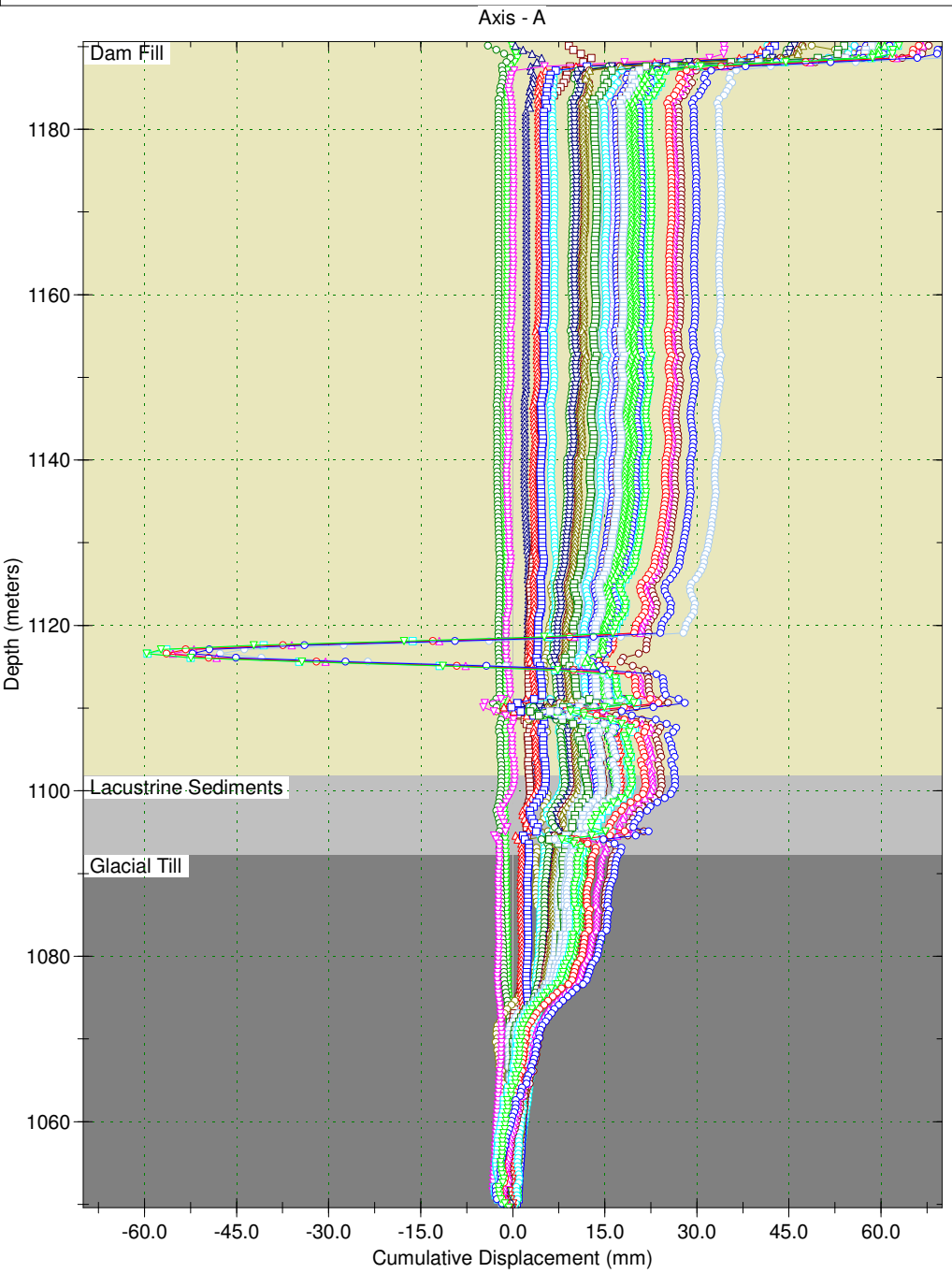
RST Instruments Ltd.

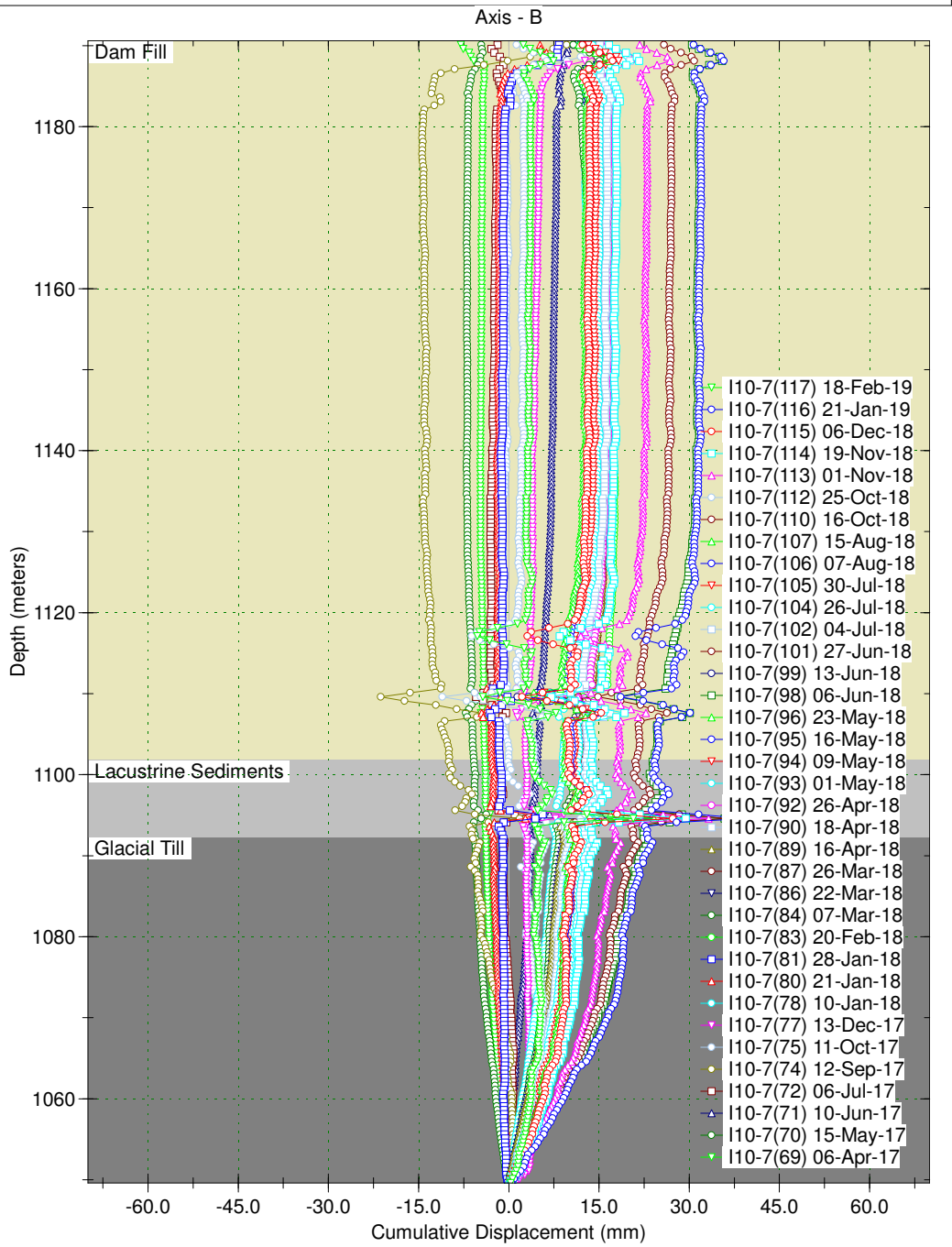
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I10-7
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1190.60 meters
Reading Depth : 141.0 meters
A+ Groove Azimuth :
Base Reading : 2017 Mar 10 21:34
Applied Azimuth : 0.0 degrees





RST Instruments Ltd.

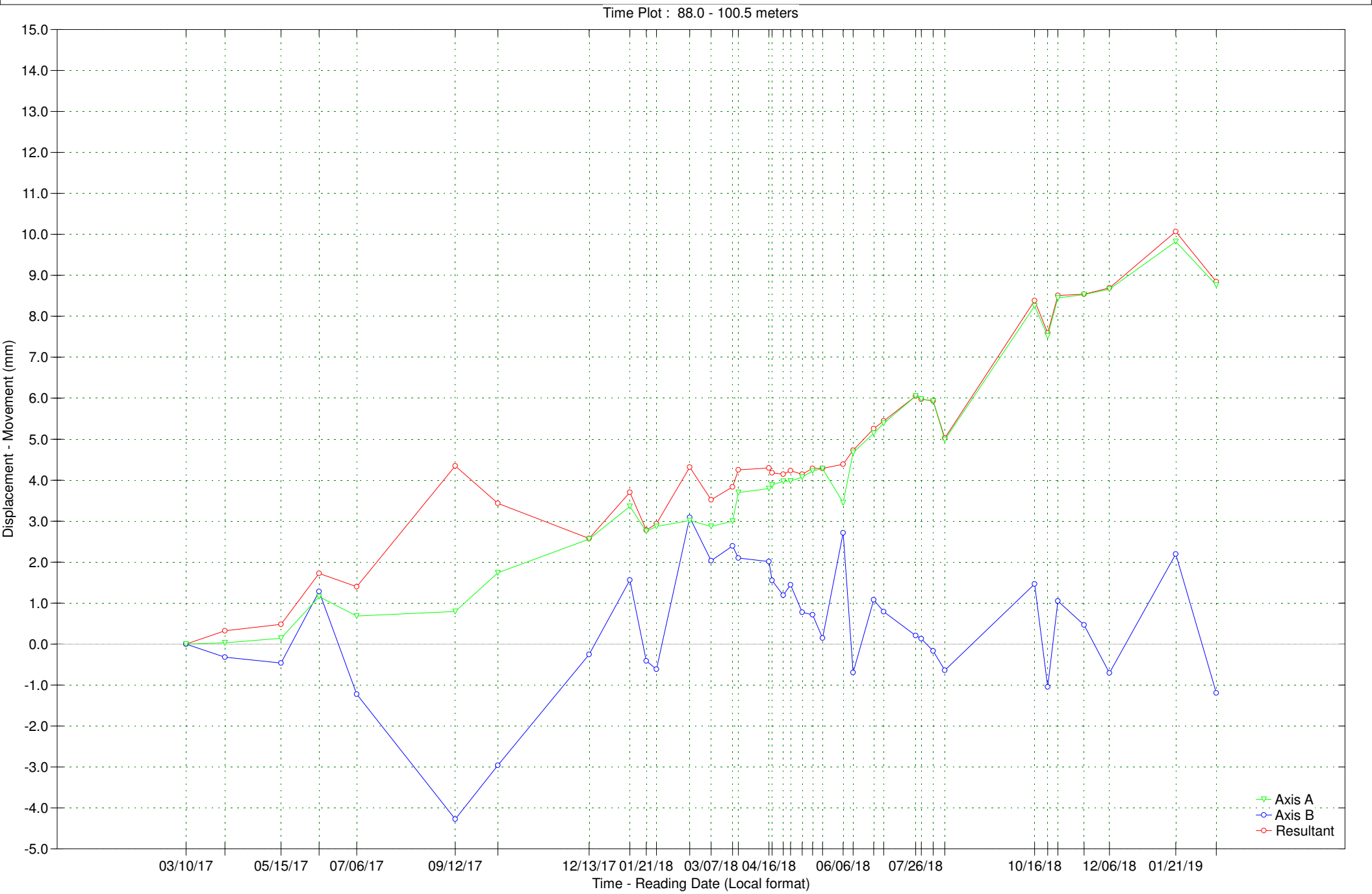
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I10-7
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1190.60 meters

Spiral Correction : N/A
Movement Depth : 88.0 - 100.5 meters
Reading Depth : 141.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 18 10:23
Initial Reading : 2017 Mar 10 21:34
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

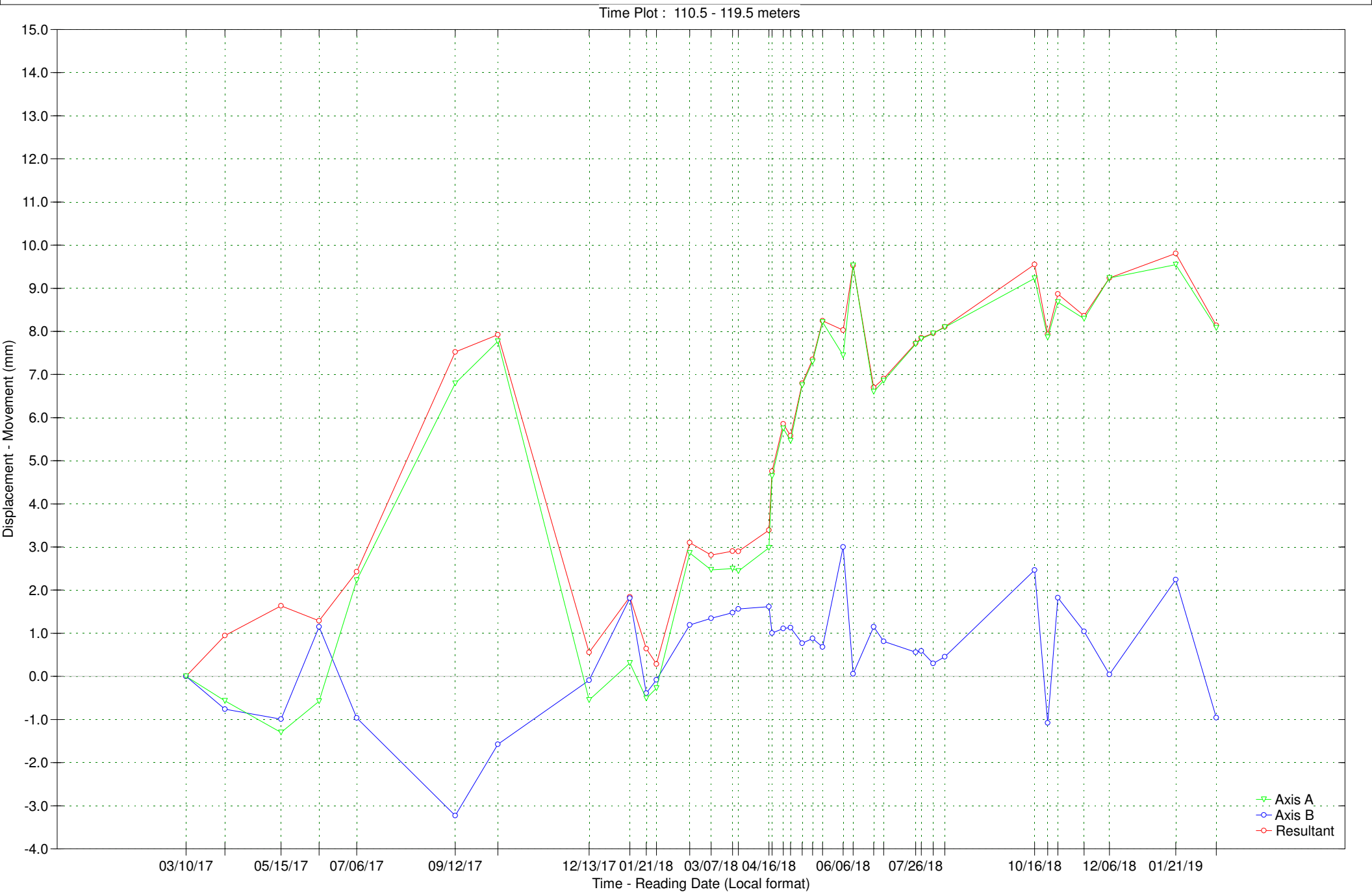
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I10-7
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1190.60 meters

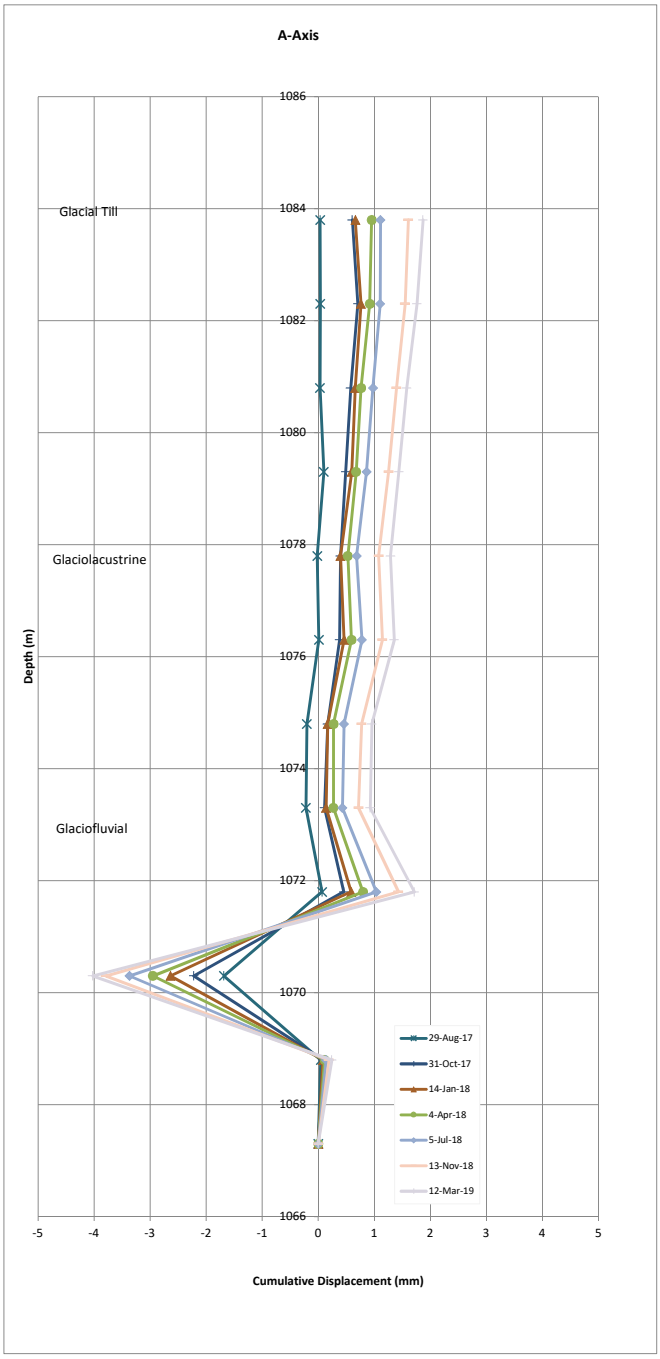
Spiral Correction : N/A
Movement Depth : 110.5 - 119.5 meters
Reading Depth : 141.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 18 10:23
Initial Reading : 2017 Mar 10 21:34
Applied Azimuth : 0.0 degrees

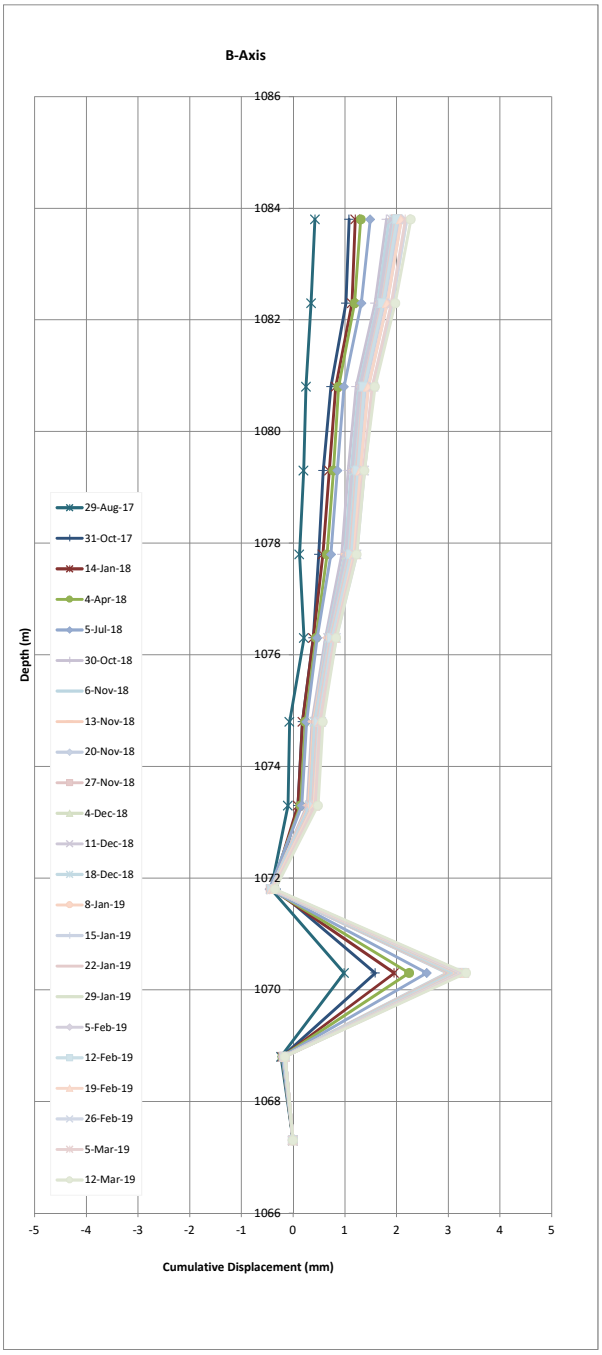


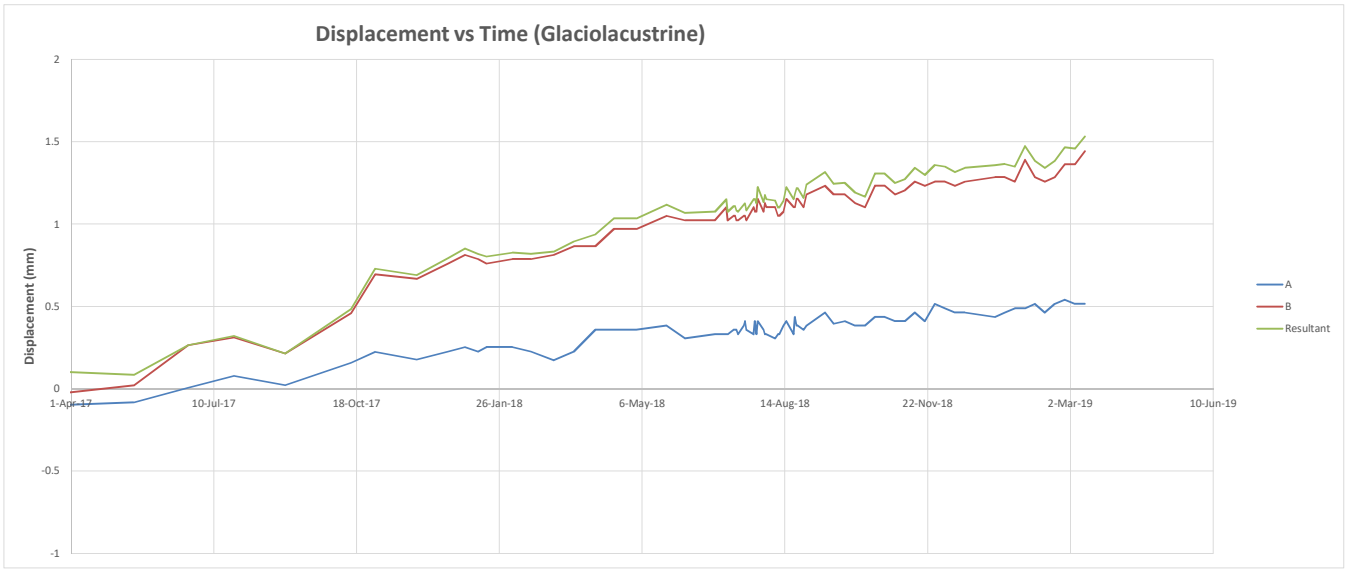
VALLEY BUTTRESS BERM

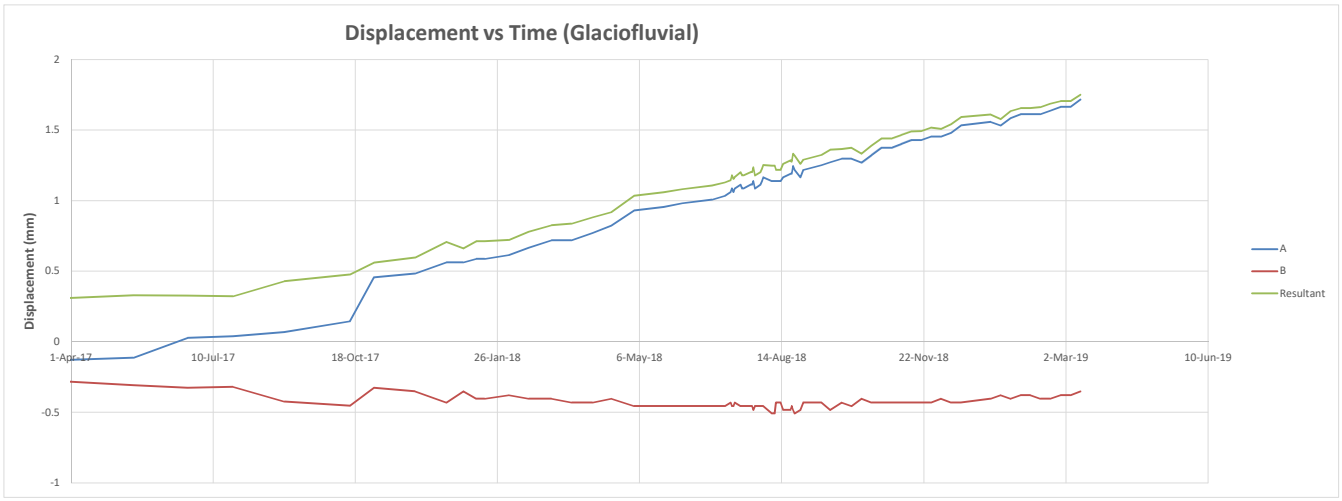
I115-24

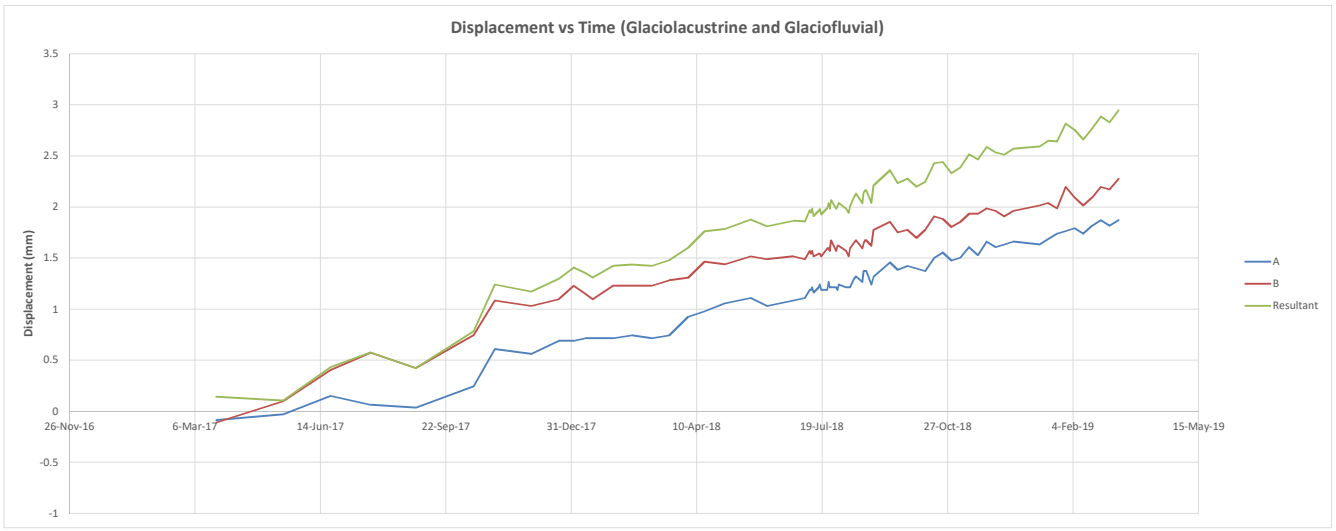
I15-24


A-Axis
Glacial Till
Glaciolacustrine
Glaciofluvial
Depth (m)
1086
1084
1082
1080
1078
1076
1074
1072
1070
1068
1066
-5
-4
-3
-2
-1
0
1
2
3
4
5
Cumulative Displacement (mm)
29-Aug-17
31-Oct-17
14-Jan-18
4-Apr-18
5-Jul-18
13-Nov-18
12-Mar-19


B-Axis
Depth (m)
1086
1084
1082
1080
1078
1076
1074
1072
1070
1068
1066
-5
-4
-3
-2
-1
0
1
2
3
4
5
Cumulative Displacement (mm)
29-Aug-17
31-Oct-17
14-Jan-18
4-Apr-18
5-Jul-18
30-Oct-18
6-Nov-18
13-Nov-18
20-Nov-18
27-Nov-18
4-Dec-18
11-Dec-18
18-Dec-18
8-Jan-19
15-Jan-19
22-Jan-19
29-Jan-19
5-Feb-19
12-Feb-19
19-Feb-19
26-Feb-19
5-Mar-19
12-Mar-19


Displacement vs Time (Glaciolacustrine)
Displacement (mm)
2
1.5
1
0.5
0
-0.5
-1
1-Apr-17
10-Jul-17
18-Oct-17
26-Jan-18
6-May-18
14-Aug-18
22-Nov-18
2-Mar-19
10-Jun-19
A
B
Resultant

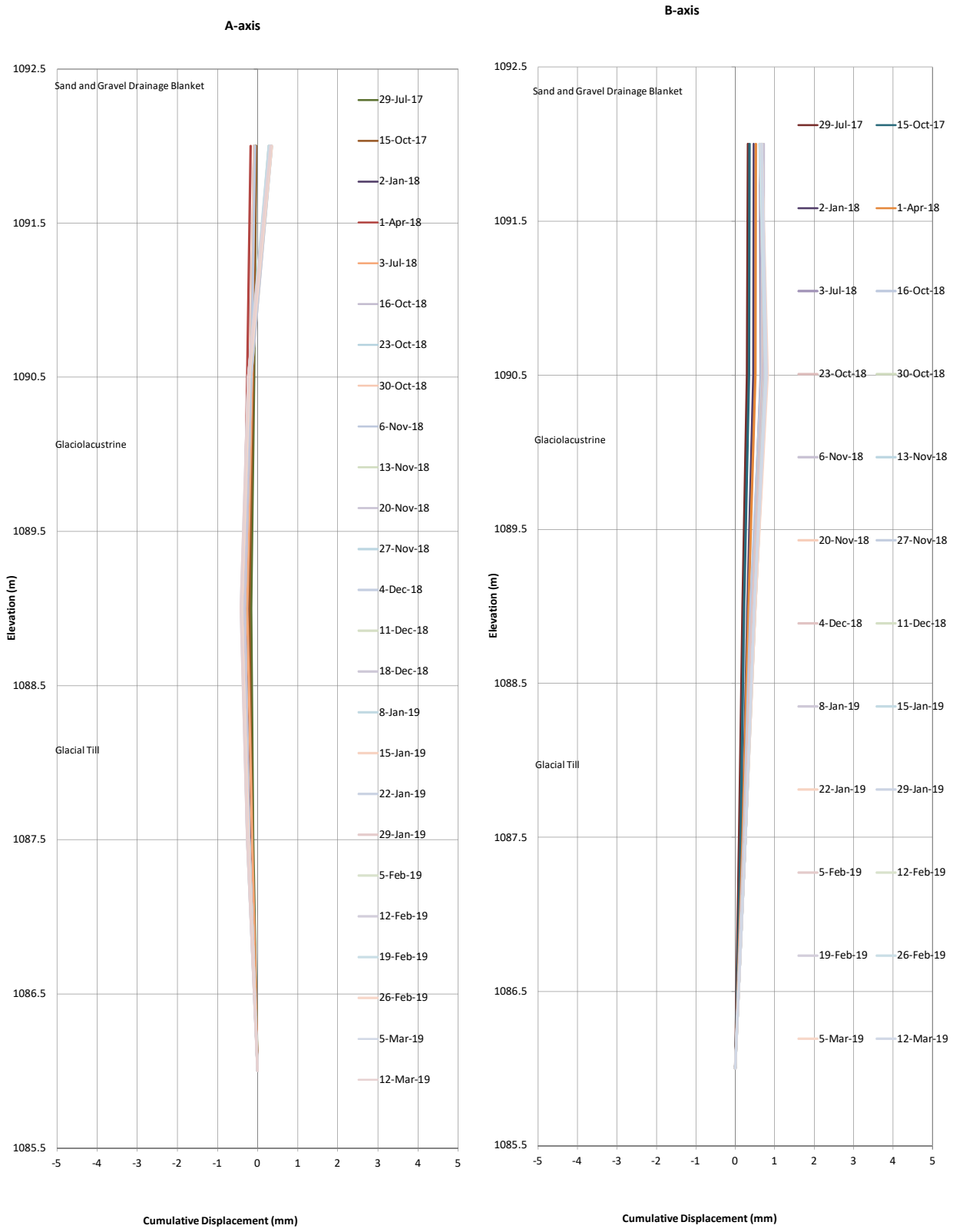

Displacement vs Time (Glaciofluvial)
Displacement (mm)
2
1.5
1
0.5
0
-0.5
-1
1-Apr-17
10-Jul-17
18-Oct-17
26-Jan-18
6-May-18
14-Aug-18
22-Nov-18
2-Mar-19
10-Jun-19
A
B
Resultant

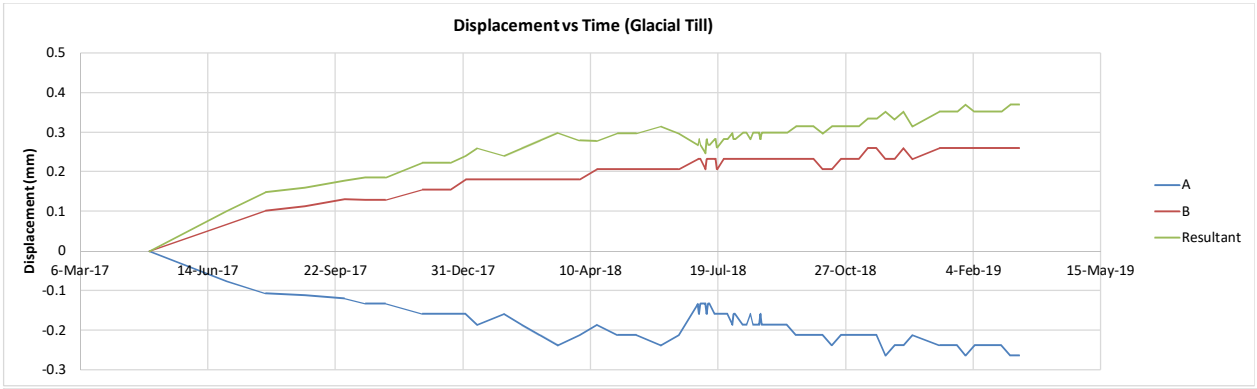

Displacement vs Time (Glaciolacustrine and Glaciofluvial)
Displacement (mm)
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
26-Nov-16
6-Mar-17
14-Jun-17
22-Sep-17
31-Dec-17
10-Apr-18
19-Jul-18
27-Oct-18
4-Feb-19
15-May-19
A
B
Resultant

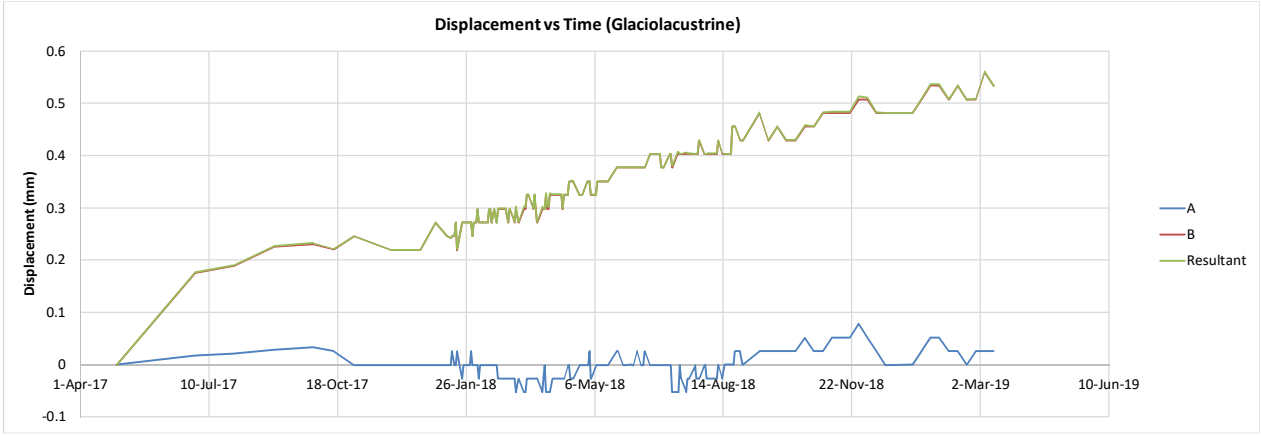
VALLEY BUTTRESS BERM

I5-27a

I15-27a


A-axis
B-axis
Sand and Gravel Drainage Blanket
Glaciolacustrine
Glacial Till
Elevation (m)
1092.5
1091.5
1090.5
1089.5
1088.5
1087.5
1086.5
1085.5
-5
-4
-3
-2
-1
0
1
2
3
4
5
Cumulative Displacement (mm)
29-Jul-17
15-Oct-17
2-Jan-18
1-Apr-18
3-Jul-18
16-Oct-18
23-Oct-18
30-Oct-18
6-Nov-18
13-Nov-18
20-Nov-18
27-Nov-18
4-Dec-18
11-Dec-18
18-Dec-18
8-Jan-19
15-Jan-19
22-Jan-19
29-Jan-19
5-Feb-19
12-Feb-19
19-Feb-19
26-Feb-19
5-Mar-19
12-Mar-19


Displacement vs Time (Glacial Till)
Displacement (mm)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
6-Mar-17
14-Jun-17
22-Sep-17
31-Dec-17
10-Apr-18
19-Jul-18
27-Oct-18
4-Feb-19
15-May-19
A
B
Resultant

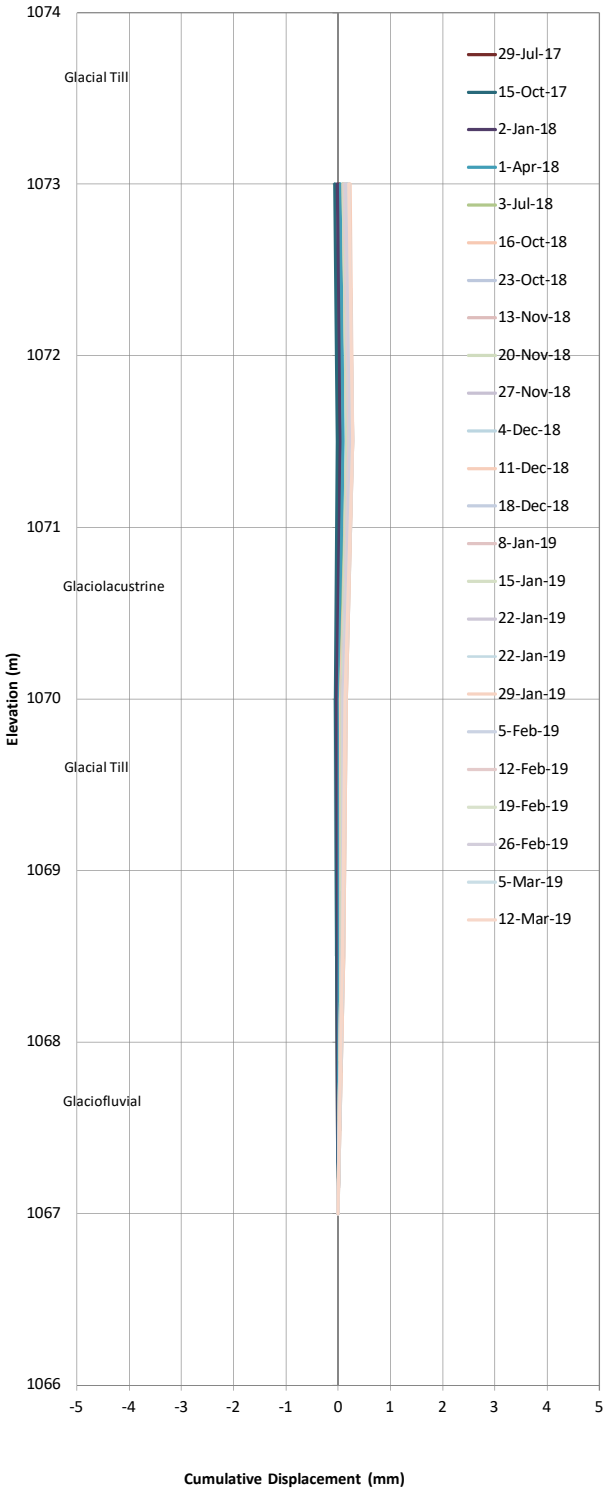

Displacement vs Time (Glaciolacustrine)
Displacement (mm)
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
1-Apr-17
10-Jul-17
18-Oct-17
26-Jan-18
6-May-18
14-Aug-18
22-Nov-18
2-Mar-19
10-Jun-19
A
B
Resultant

VALLEY BUTTRESS BERM

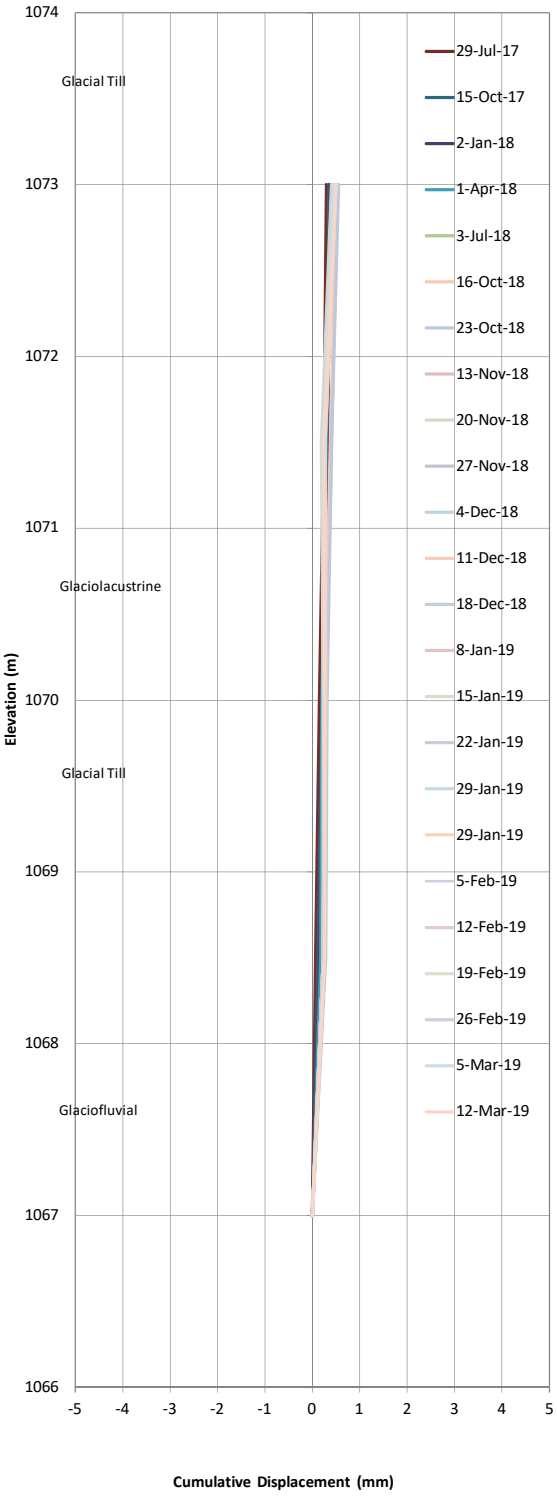
I15-27b

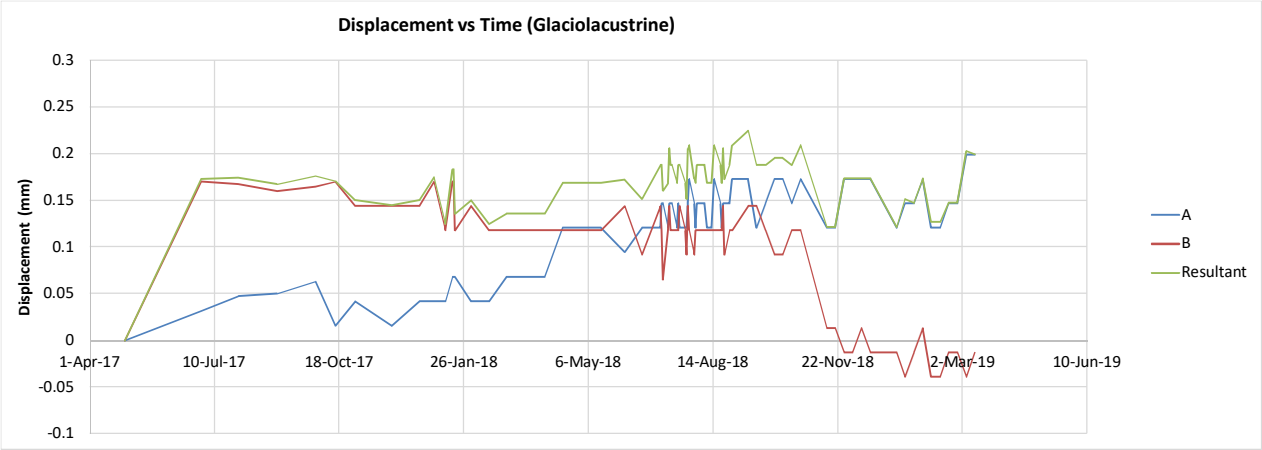
I15-27b

A-axis



B-axis




Displacement vs Time (Glaciolacustrine)
Displacement (mm)
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
1-Apr-17
10-Jul-17
18-Oct-17
26-Jan-18
6-May-18
14-Aug-18
22-Nov-18
2-Mar-19
10-Jun-19
A
B
Resultant

VALLEY BUTTRESS BERM

I17-01

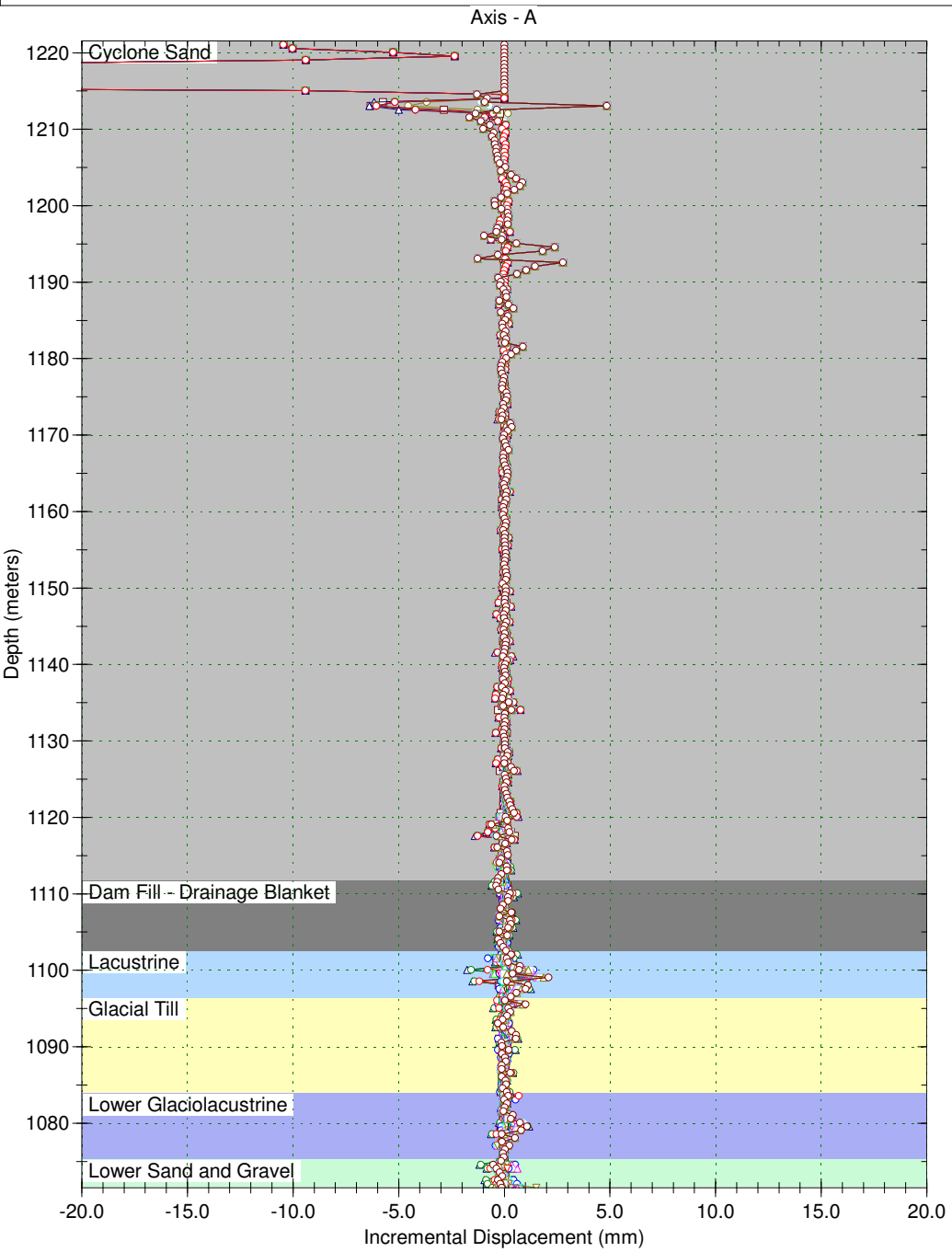
RST Instruments Ltd.

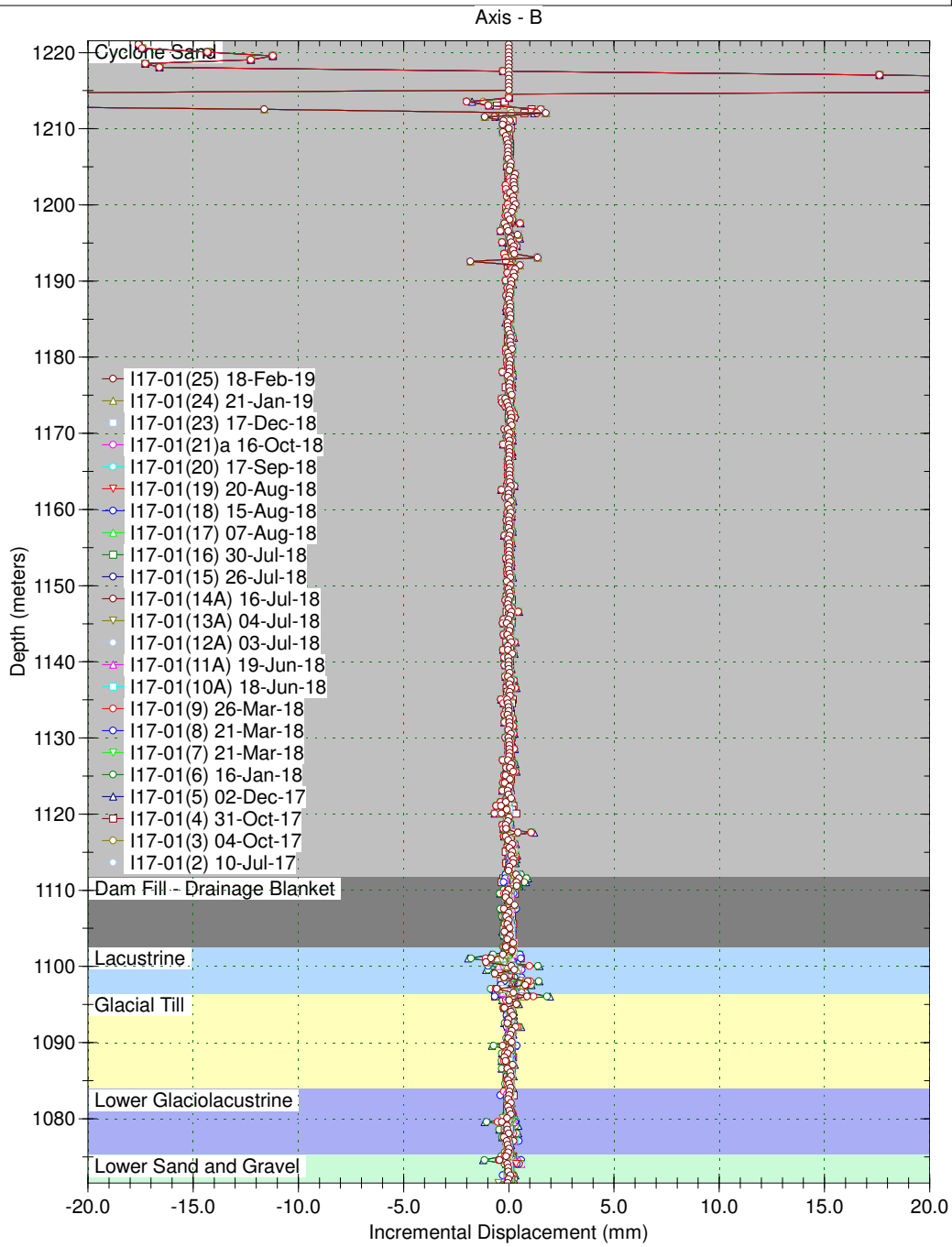
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : RMR Historical
Project : I17-01
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1221.56 meters
Reading Depth : 142.5 meters
A+ Groove Azimuth :
Base Reading : 2017 Jul 10 11:52
Applied Azimuth : 0.0 degrees





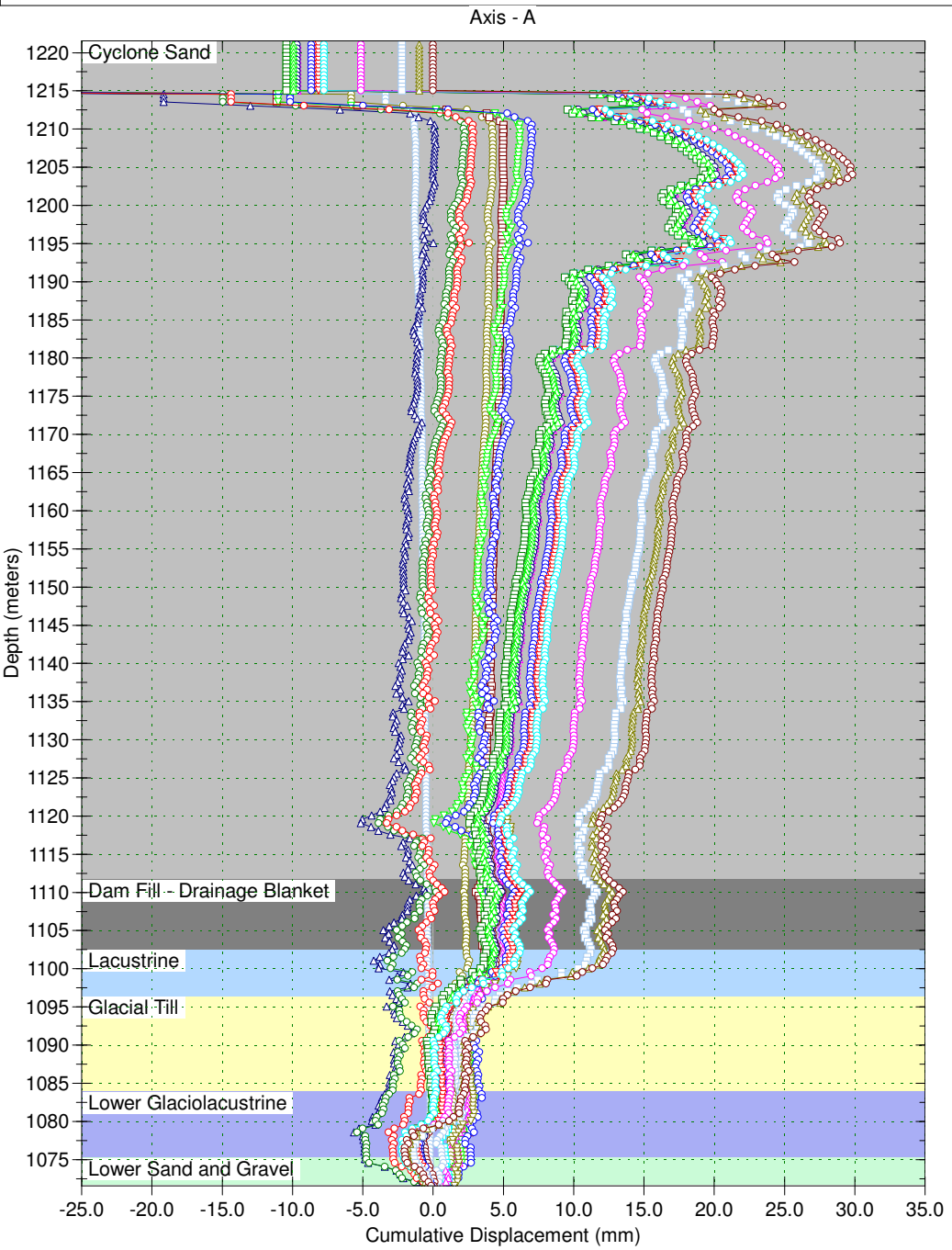
RST Instruments Ltd.

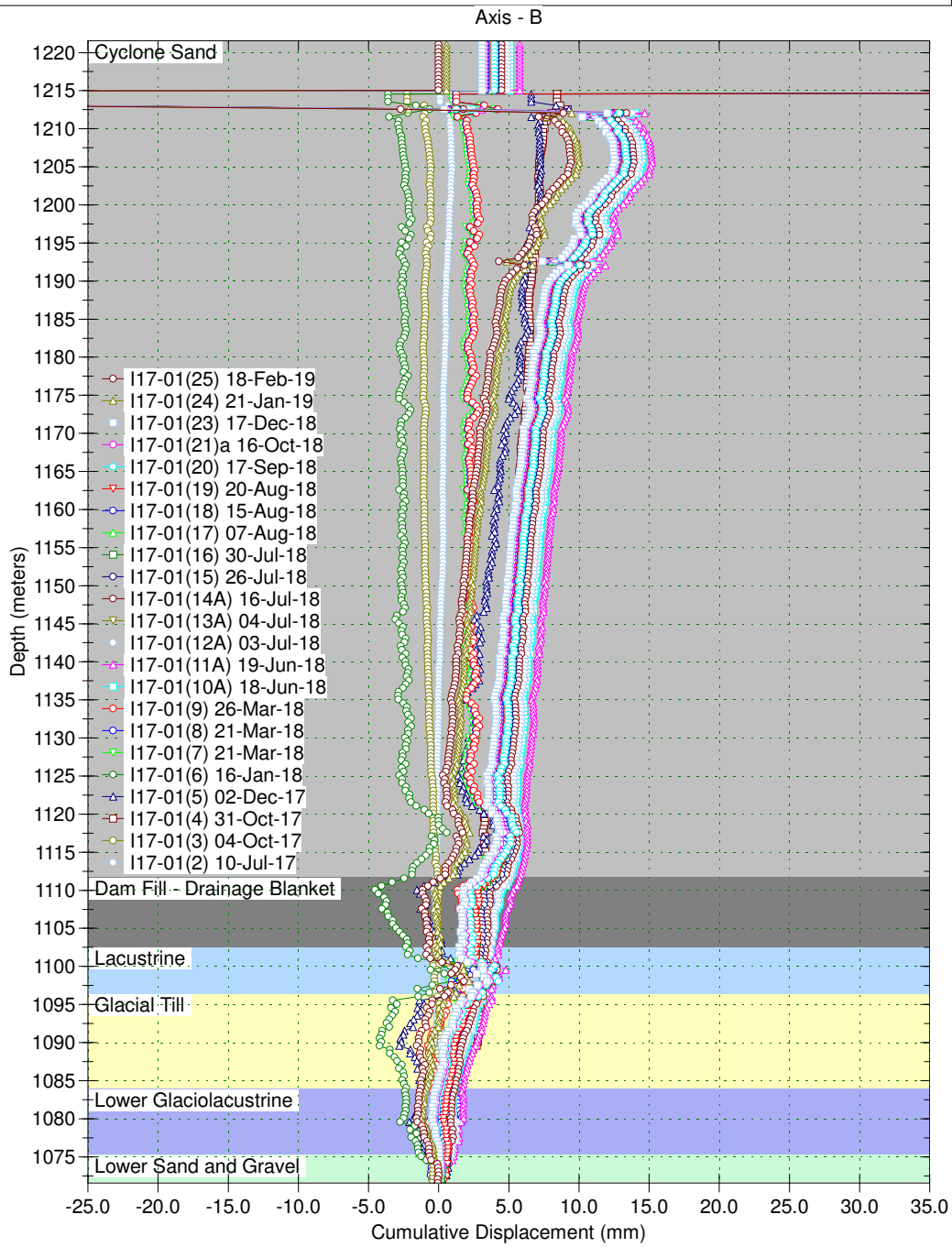
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : RMR Historical
Project : I17-01
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1221.56 meters
Reading Depth : 142.5 meters
A+ Groove Azimuth :
Base Reading : 2017 Jul 10 11:52
Applied Azimuth : 0.0 degrees





RST Instruments Ltd.

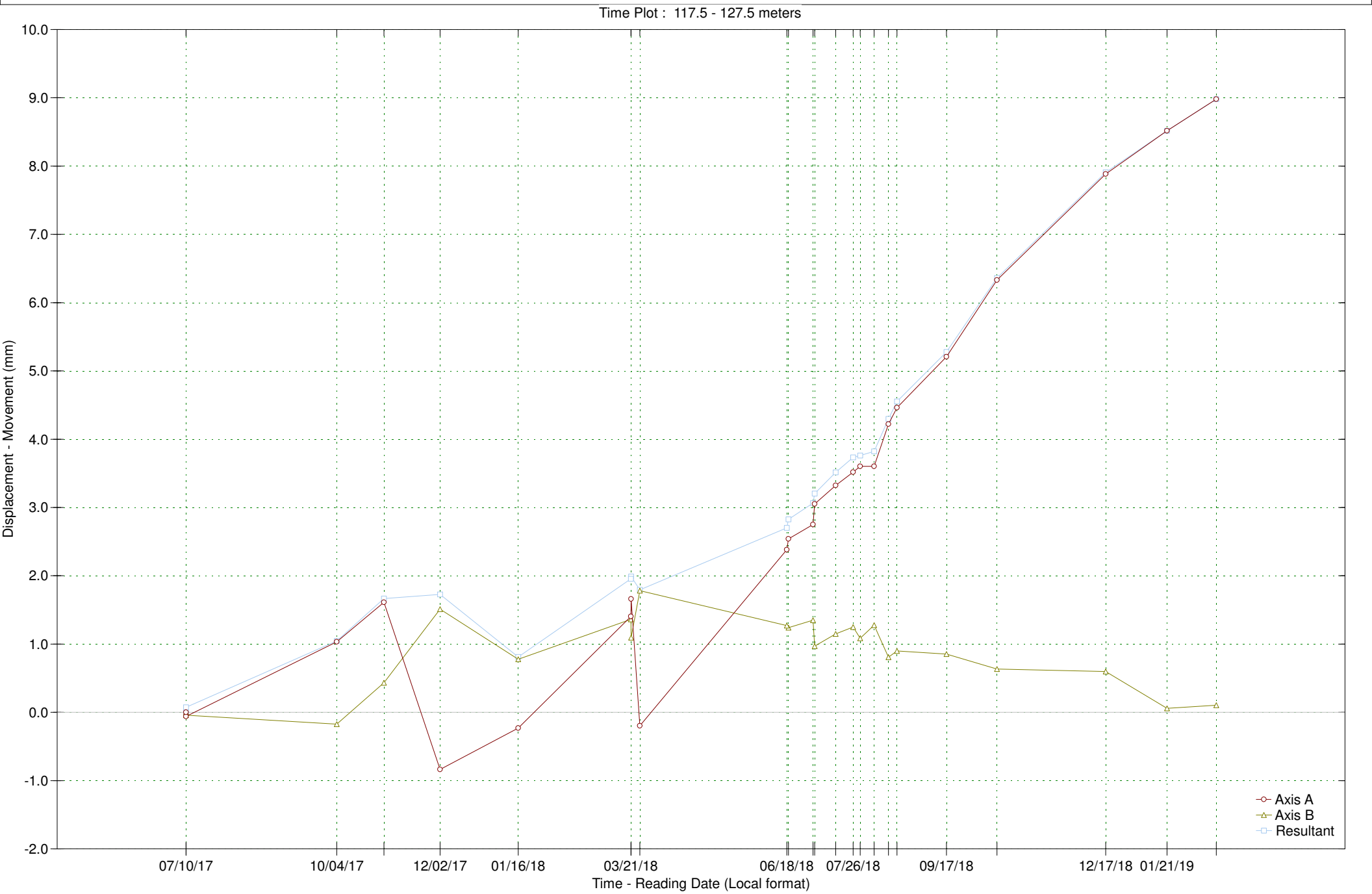
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : RMR Historical
Project : I17-01
Location :
Northing :
Easting :
Collar :
Collar Elev : 1221.56 meters

Spiral Correction : N/A
Movement Depth : 117.5 - 127.5 meters
Reading Depth : 150.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 18 13:20
Initial Reading : 2017 Jul 10 11:52
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

TIME PLOT

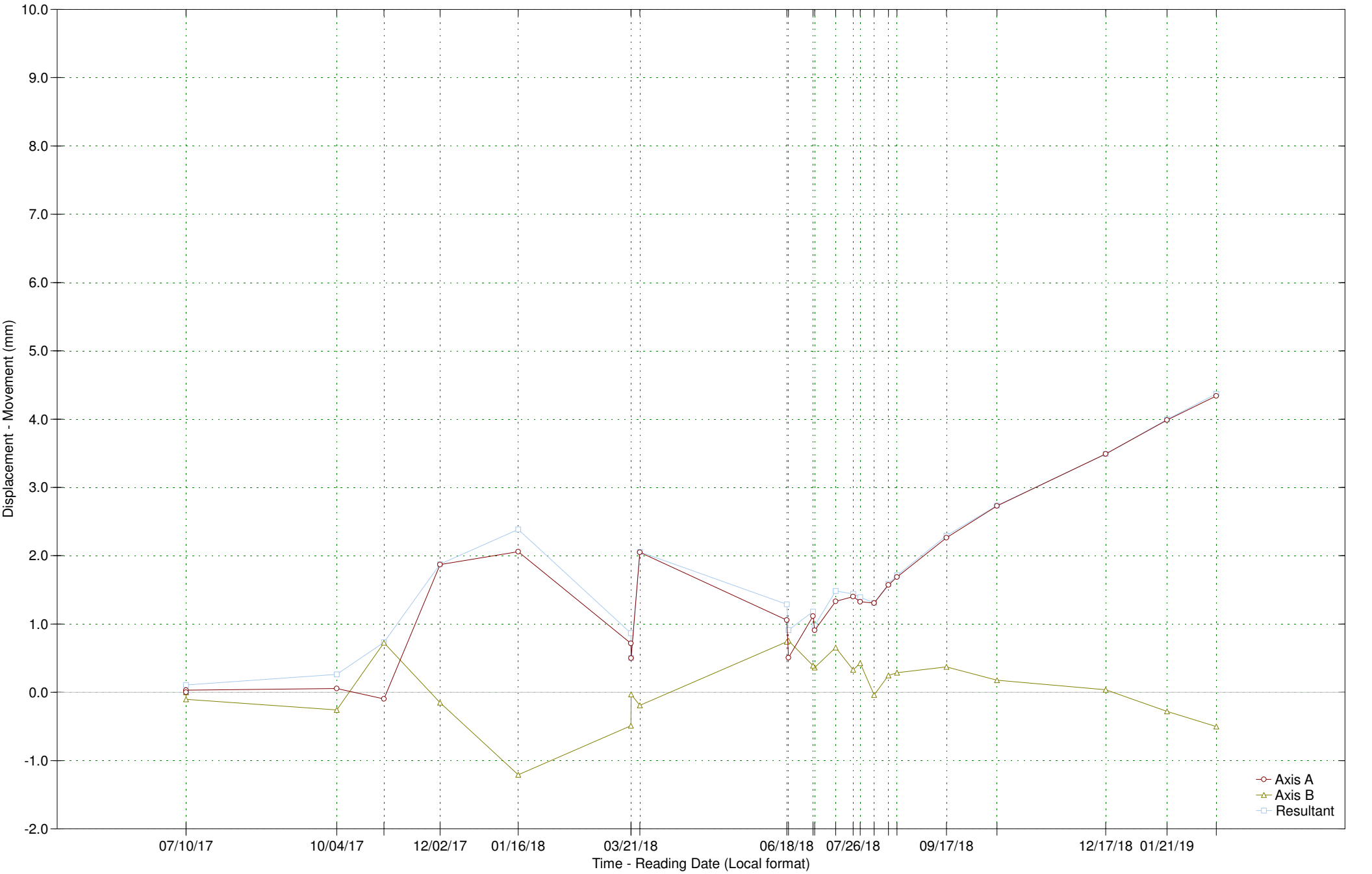
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : RMR Historical
Project : I17-01
Location :
Northing :
Easting :
Collar :
Collar Elev : 1221.56 meters

Spiral Correction : N/A
Movement Depth : 136.0 - 146.0 meters
Reading Depth : 150.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 18 13:20
Initial Reading : 2017 Jul 10 11:52
Applied Azimuth : 0.0 degrees

Time Plot : 136.0 - 146.0 meters



VALLEY BUTTRESS BERM

I17-02

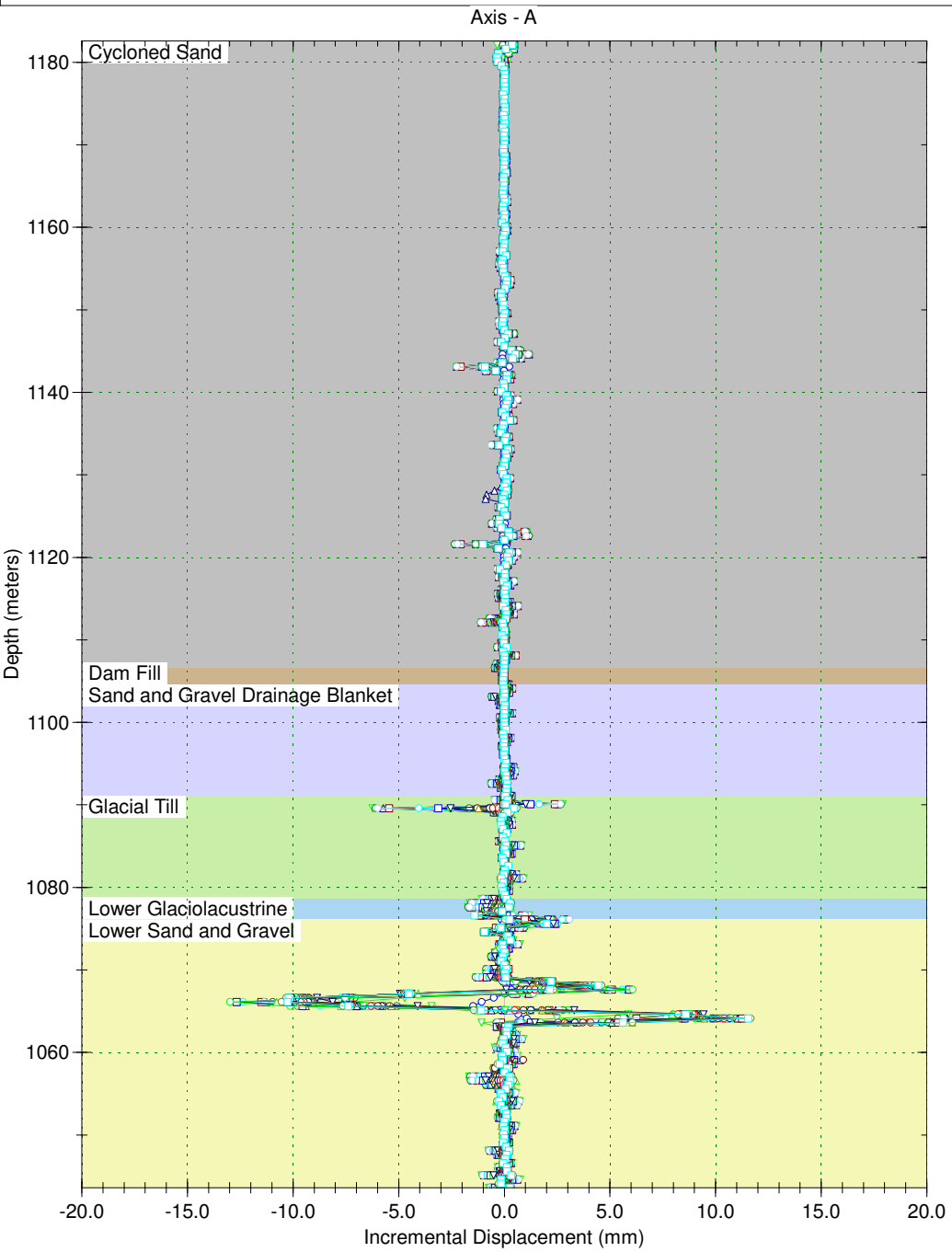
RST Instruments Ltd.

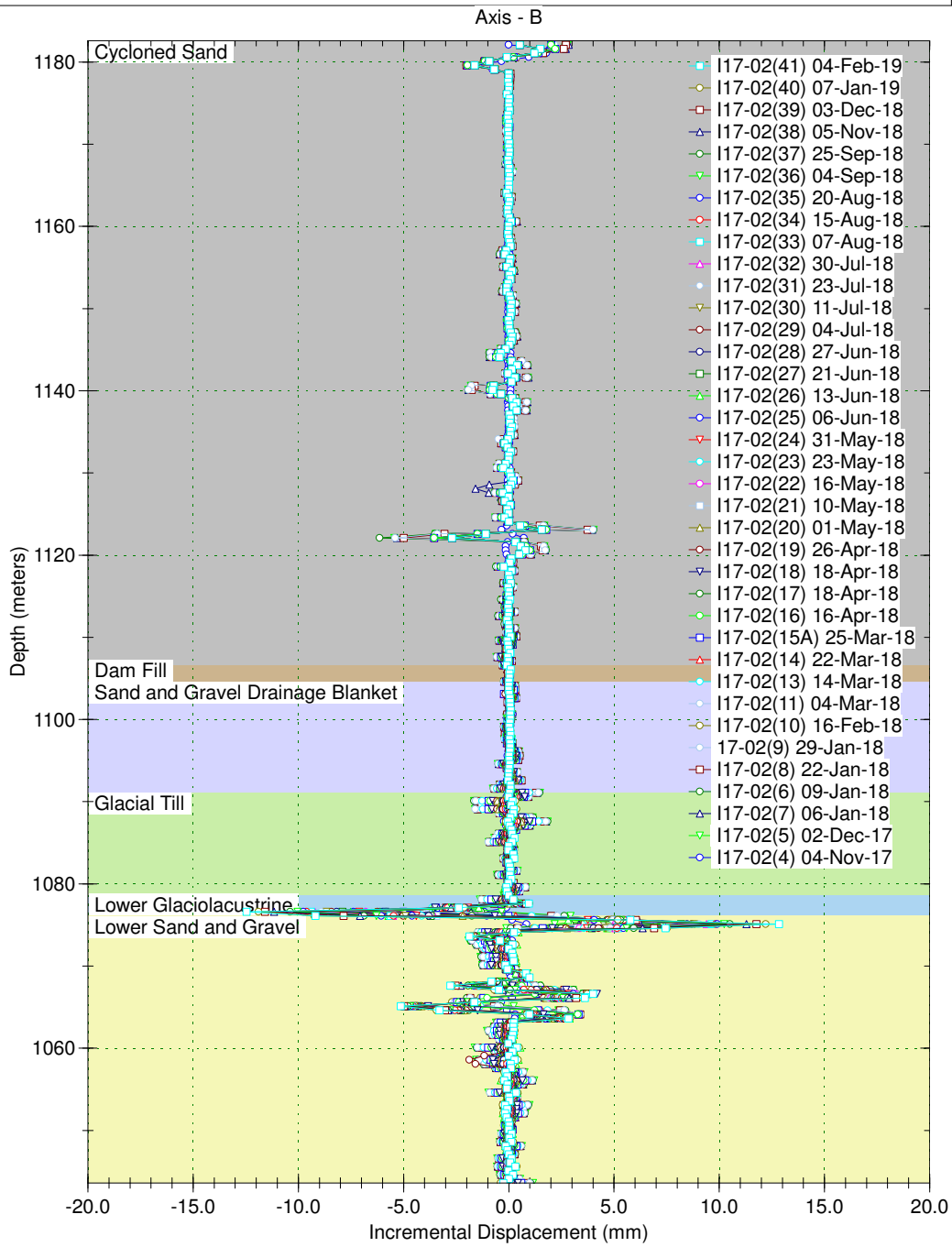
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I17-02
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1182.60 meters
Reading Depth : 139.0 meters
A+ Groove Azimuth :
Base Reading : 2017 Sep 29 13:56
Applied Azimuth : 0.0 degrees





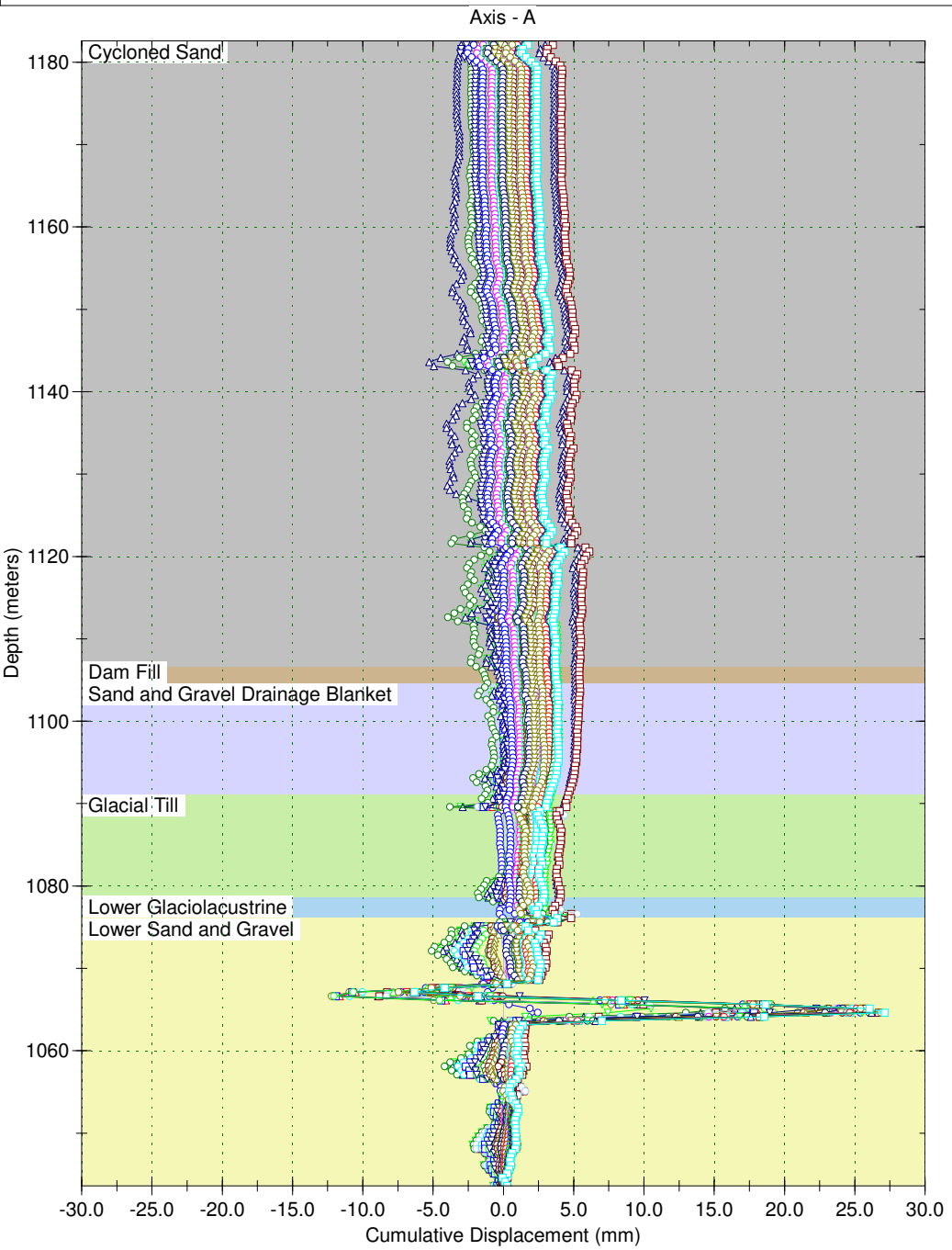
RST Instruments Ltd.

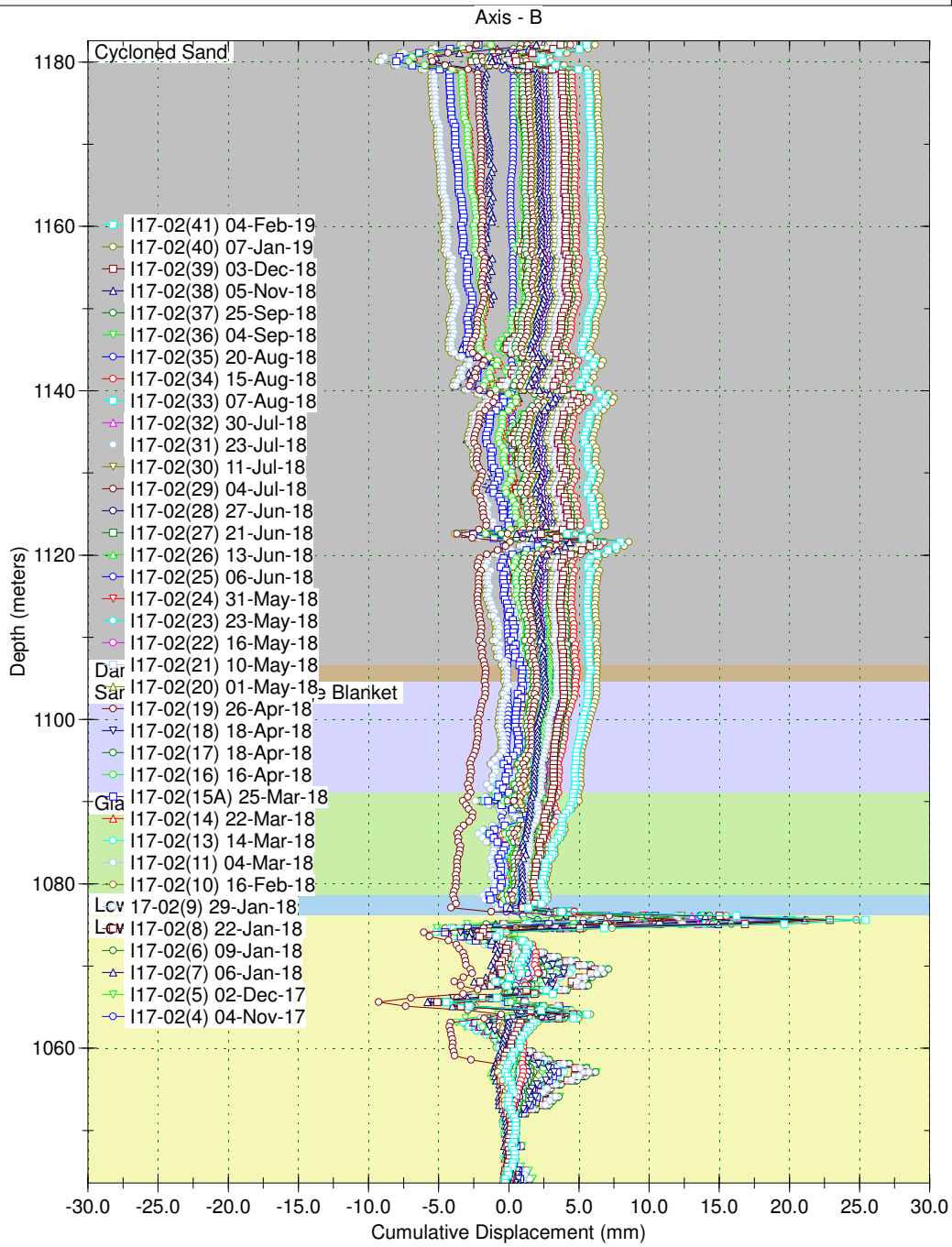
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I17-02
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1182.60 meters
Reading Depth : 139.0 meters
A+ Groove Azimuth :
Base Reading : 2017 Sep 29 13:56
Applied Azimuth : 0.0 degrees





RST Instruments Ltd.

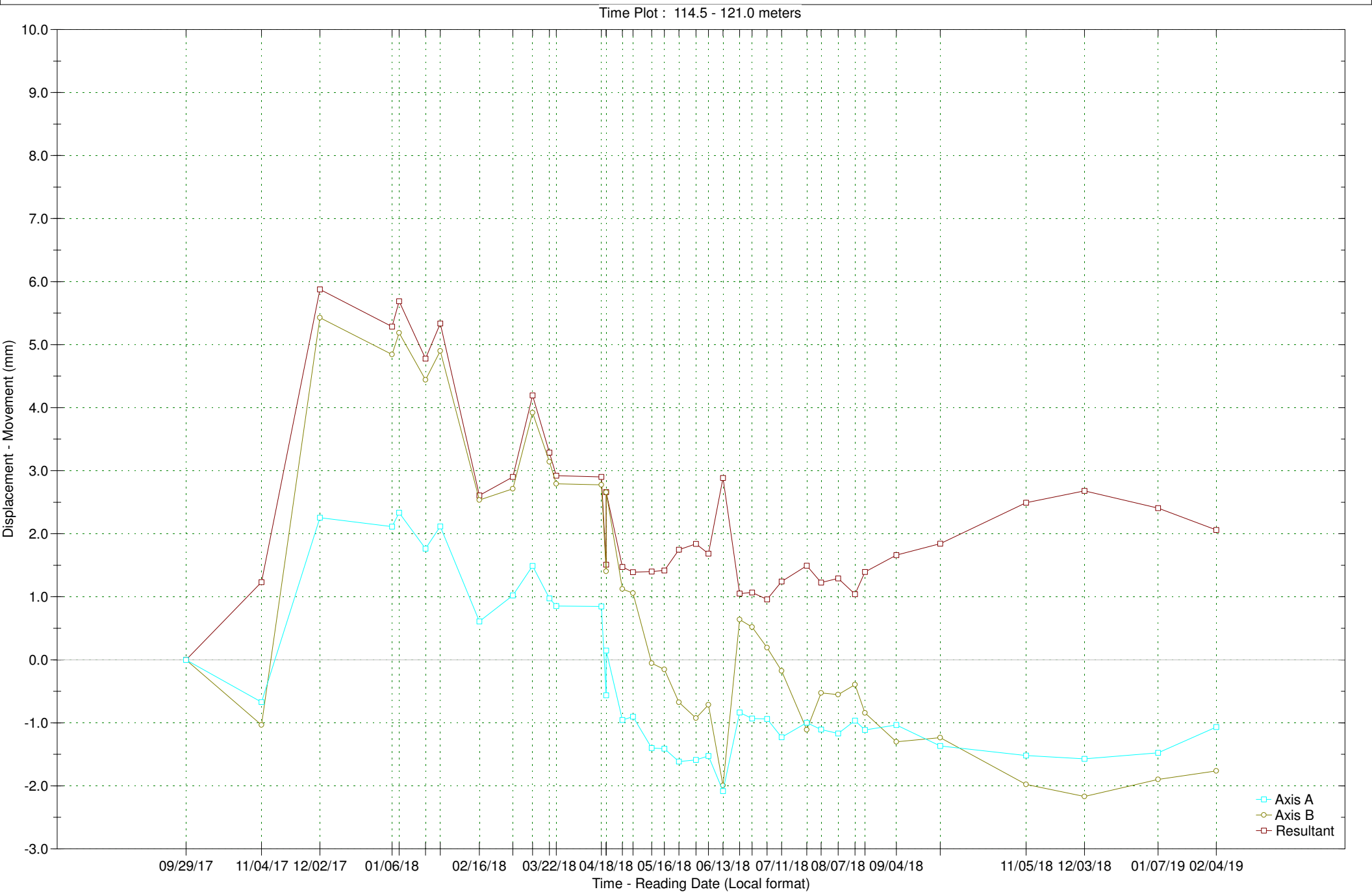
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I17-02
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1182.60 meters

Spiral Correction : Enabled
Movement Depth : 114.5 - 121.0 meters
Reading Depth : 139.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 04 10:50
Initial Reading : 2017 Sep 29 13:56
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

TIME PLOT

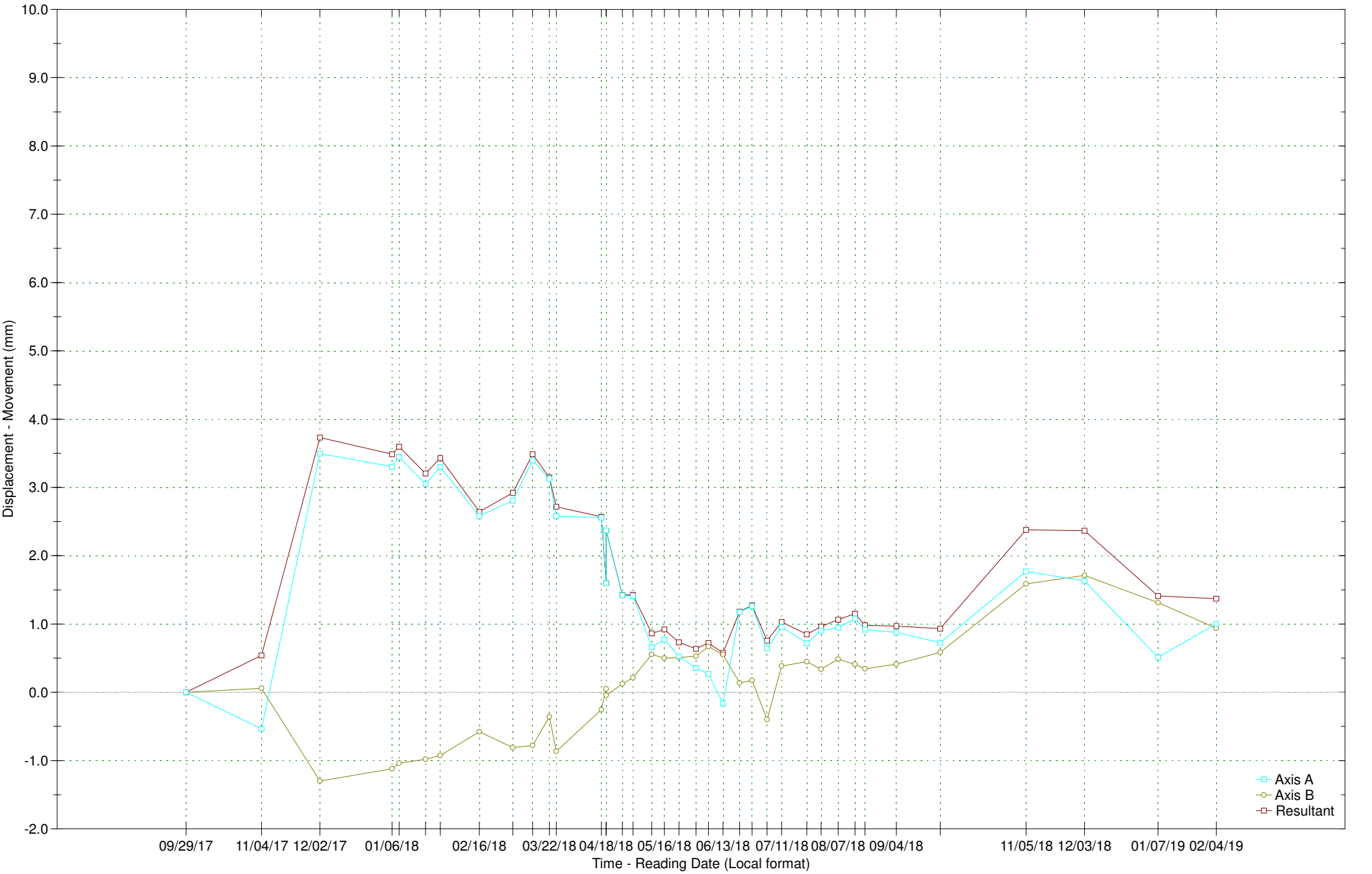
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I17-02
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1182.60 meters

Spiral Correction : Enabled
Movement Depth : 103.0 - 110.0 meters
Reading Depth : 139.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 04 10:50
Initial Reading : 2017 Sep 29 13:56
Applied Azimuth : 0.0 degrees

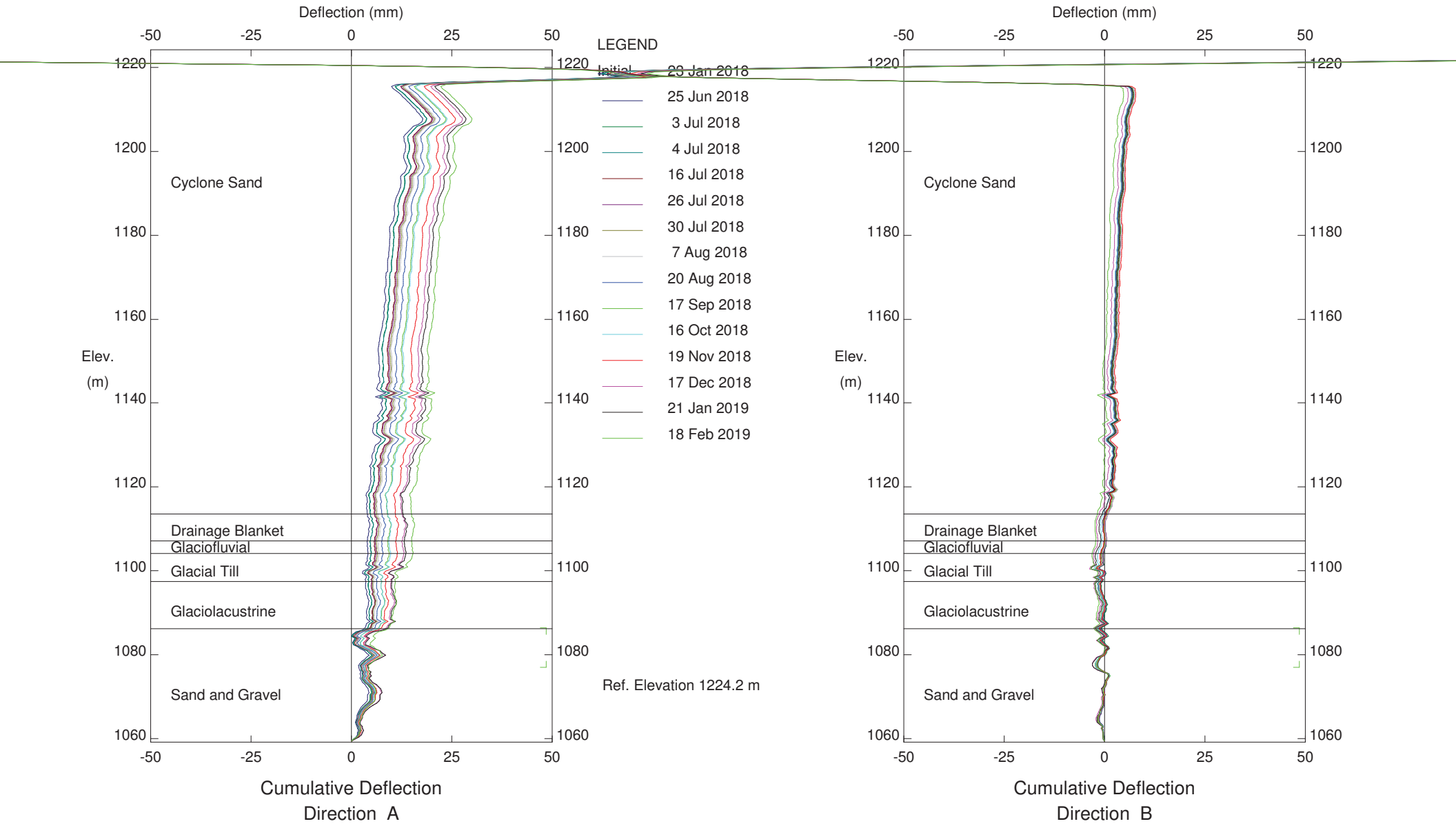
Time Plot : 103.0 - 110.0 meters



VALLEY BUTTRESS BERM

I17-06

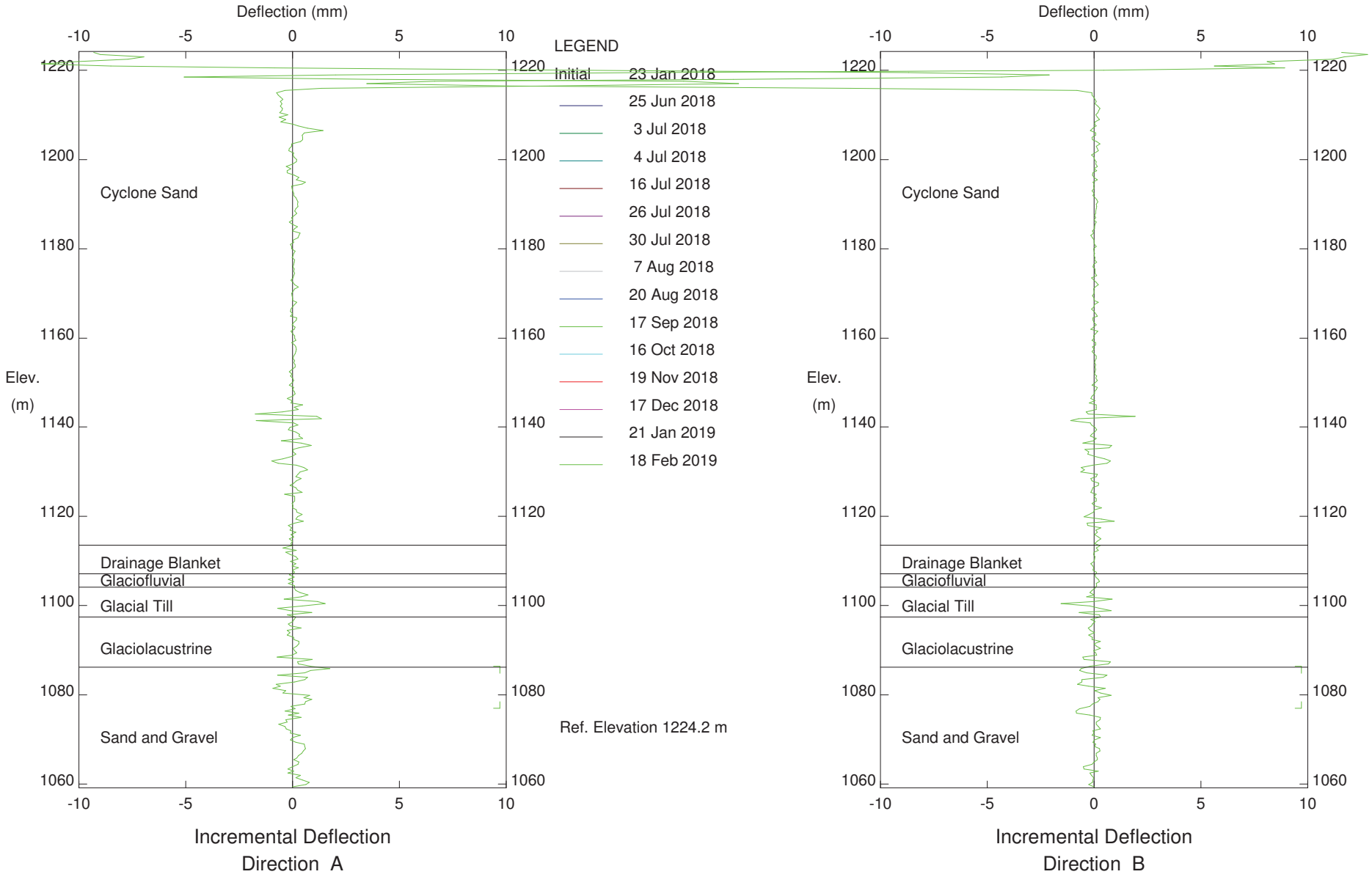
Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded,,,, Inclinometer I17-06,,,

V:\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\L-L Dam\SI Monitoring\Inclinalysis Files\1----Including dam fill\I17-06\GTILT\I17-06.gtl

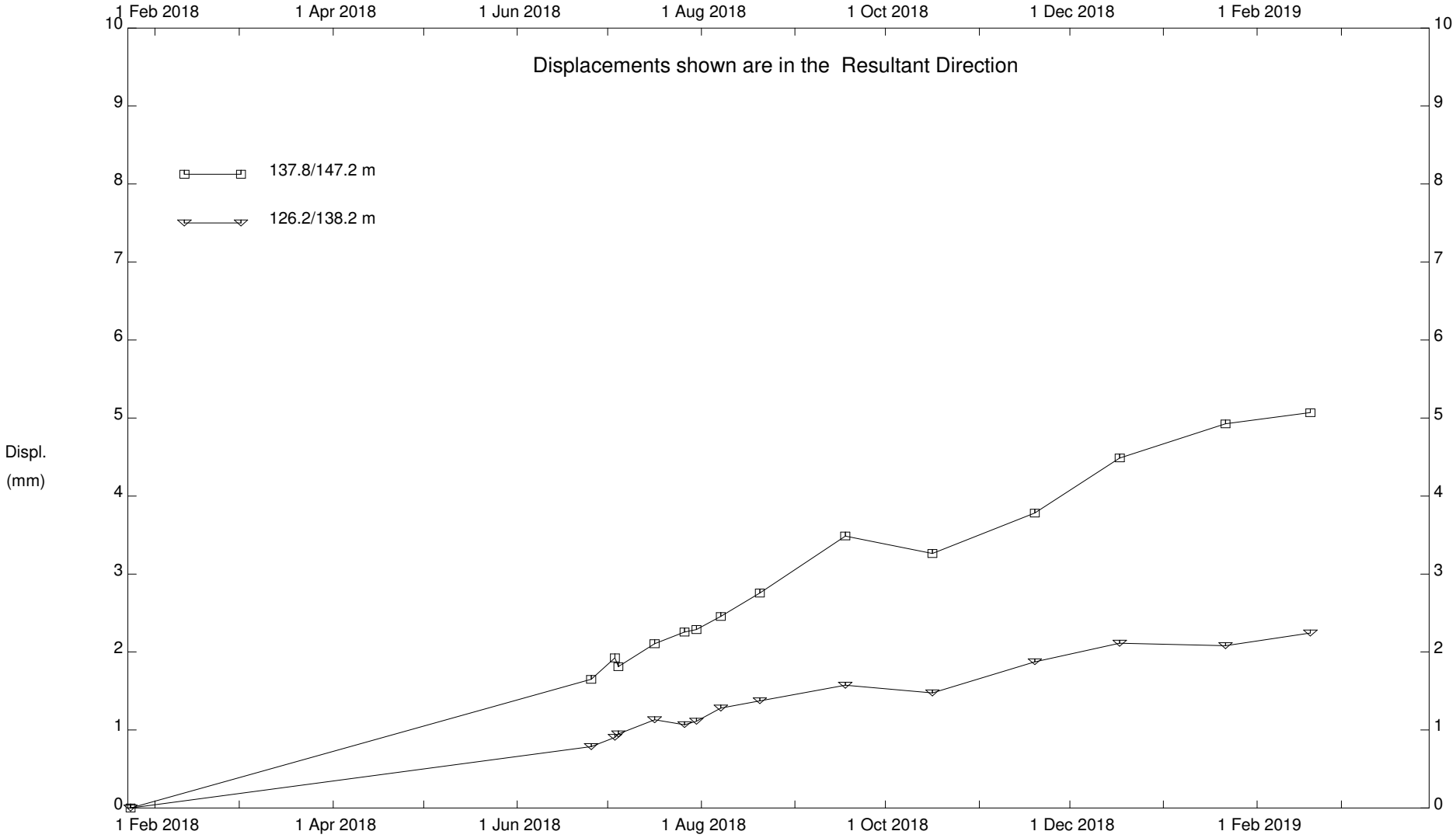
Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded,,,, Inclinometer I17-06,,,

V:\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\L-L Dam\SI Monitoring\Inclinalysis Files\1----Including dam fill\I17-06\GTILT\I17-06.gtl

Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded,,,, Inclinometer I17-06,,,

VALLEY BUTTRESS BERM

I17-09

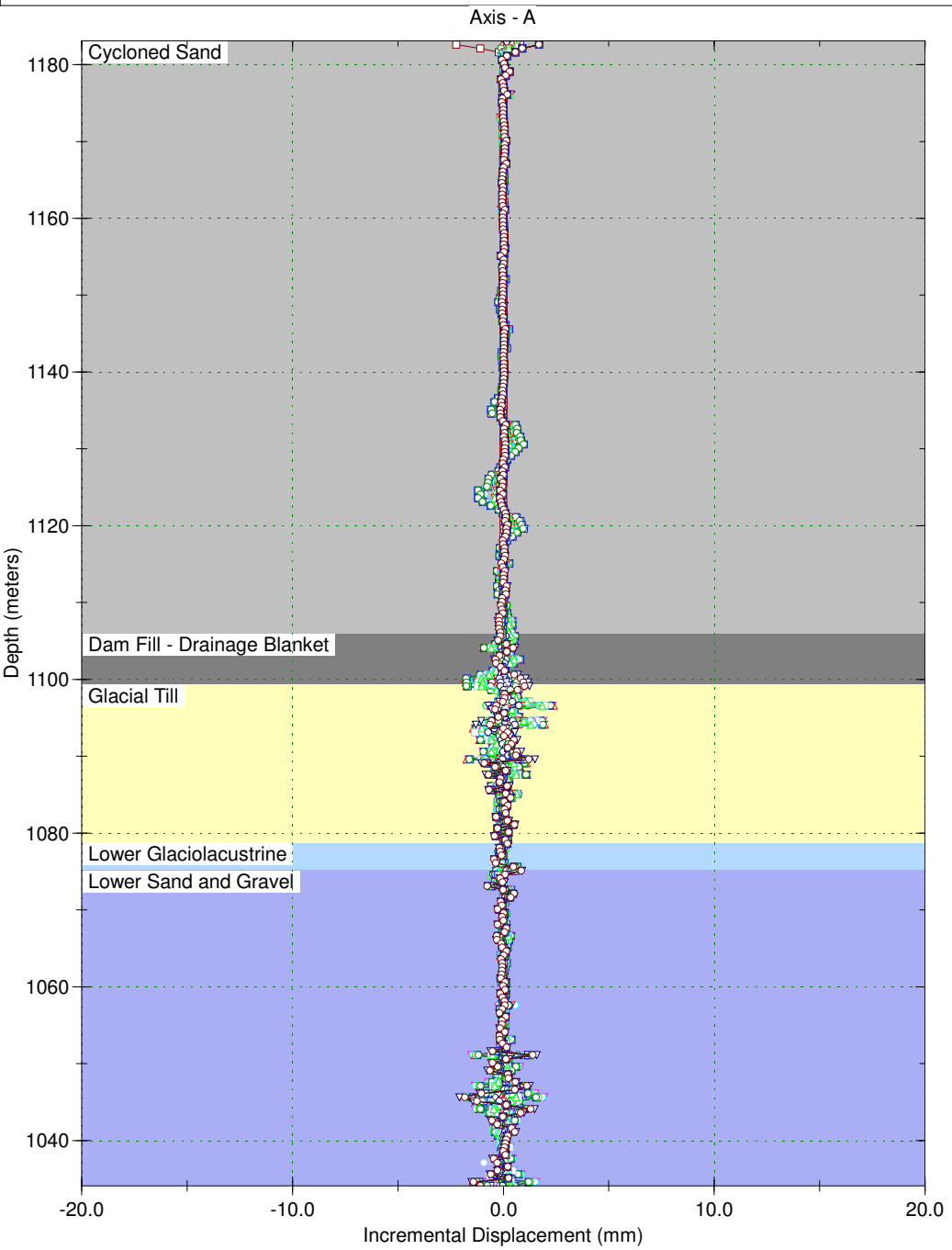
RST Instruments Ltd.

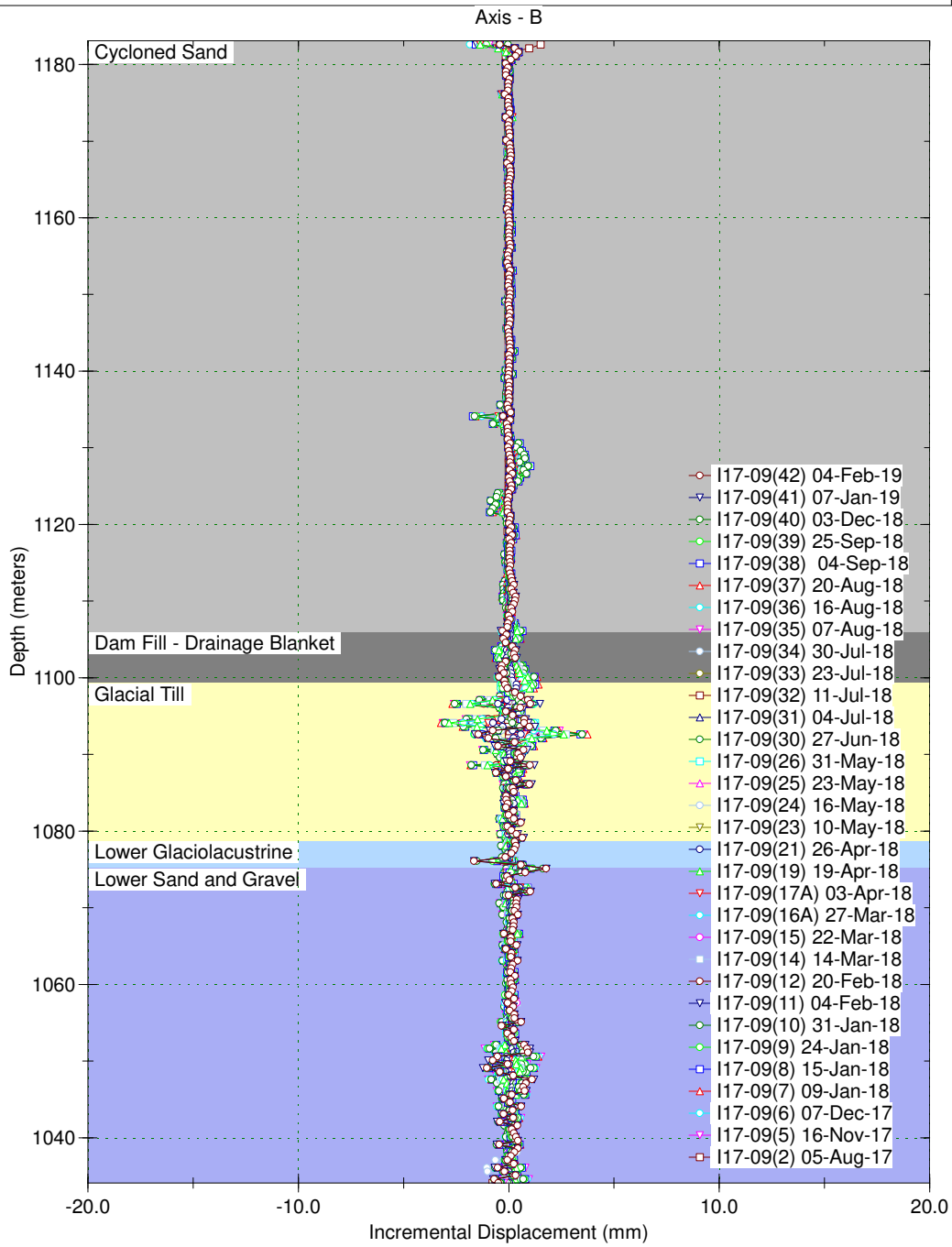
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I17-09
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : Enabled
Collar Elevation : :1183.10 meters
Reading Depth : 149.0 meters
A+ Groove Azimuth :
Base Reading : 2017 Aug 05 20:11
Applied Azimuth : 0.0 degrees





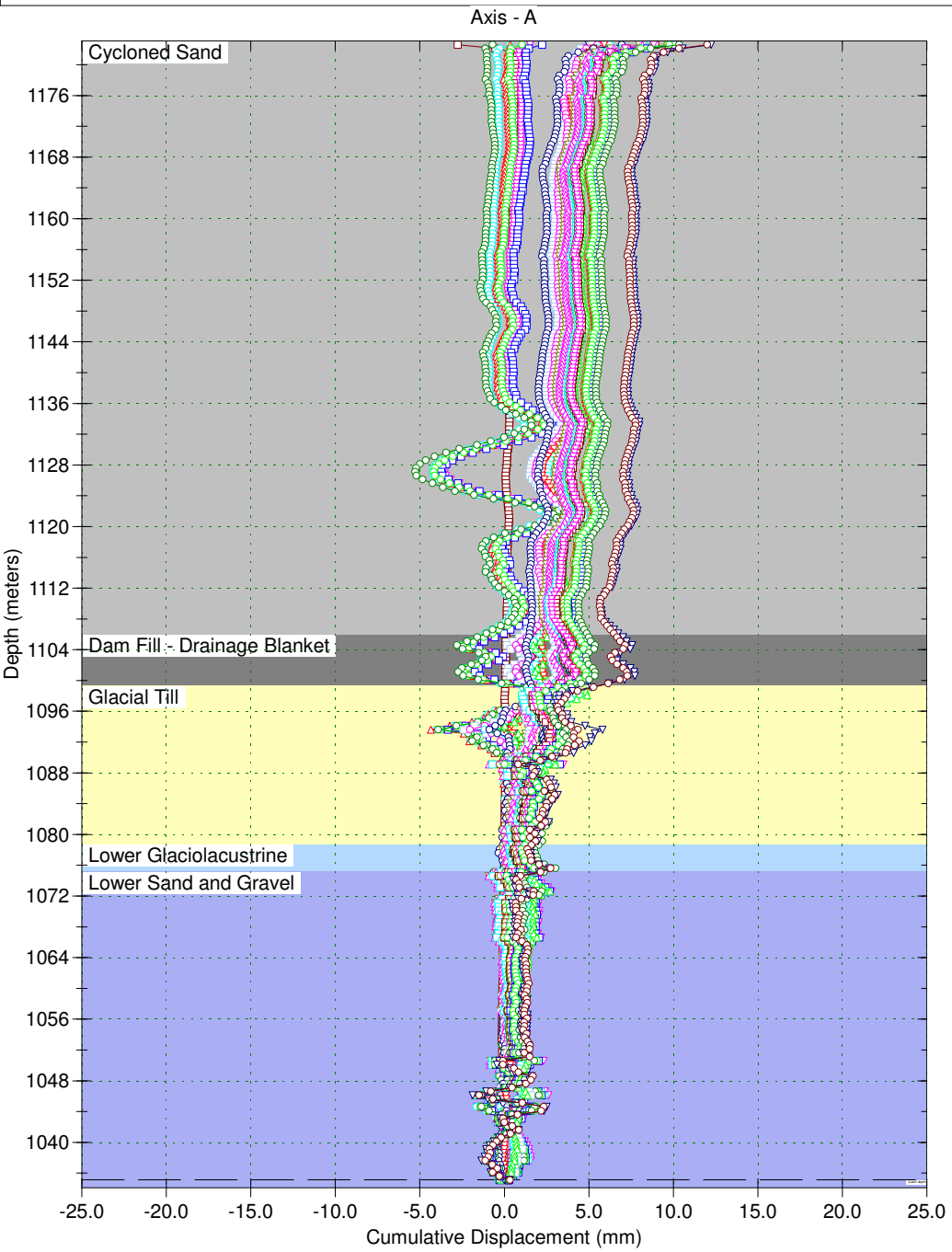
RST Instruments Ltd.

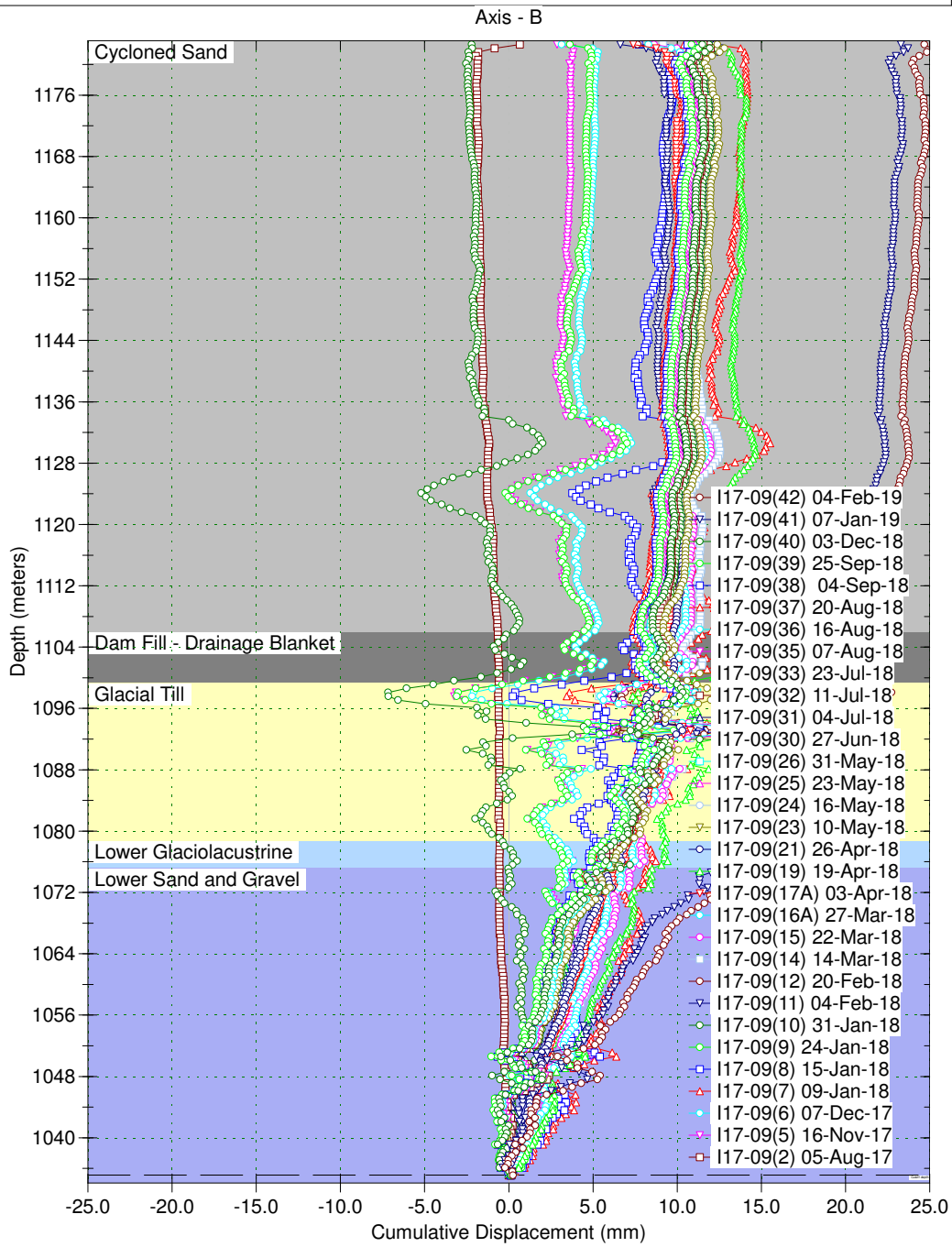
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I17-09
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1183.10 meters
Reading Depth : 149.0 meters
A+ Groove Azimuth :
Base Reading : 2017 Aug 05 20:11
Applied Azimuth : 0.0 degrees





RST Instruments Ltd.

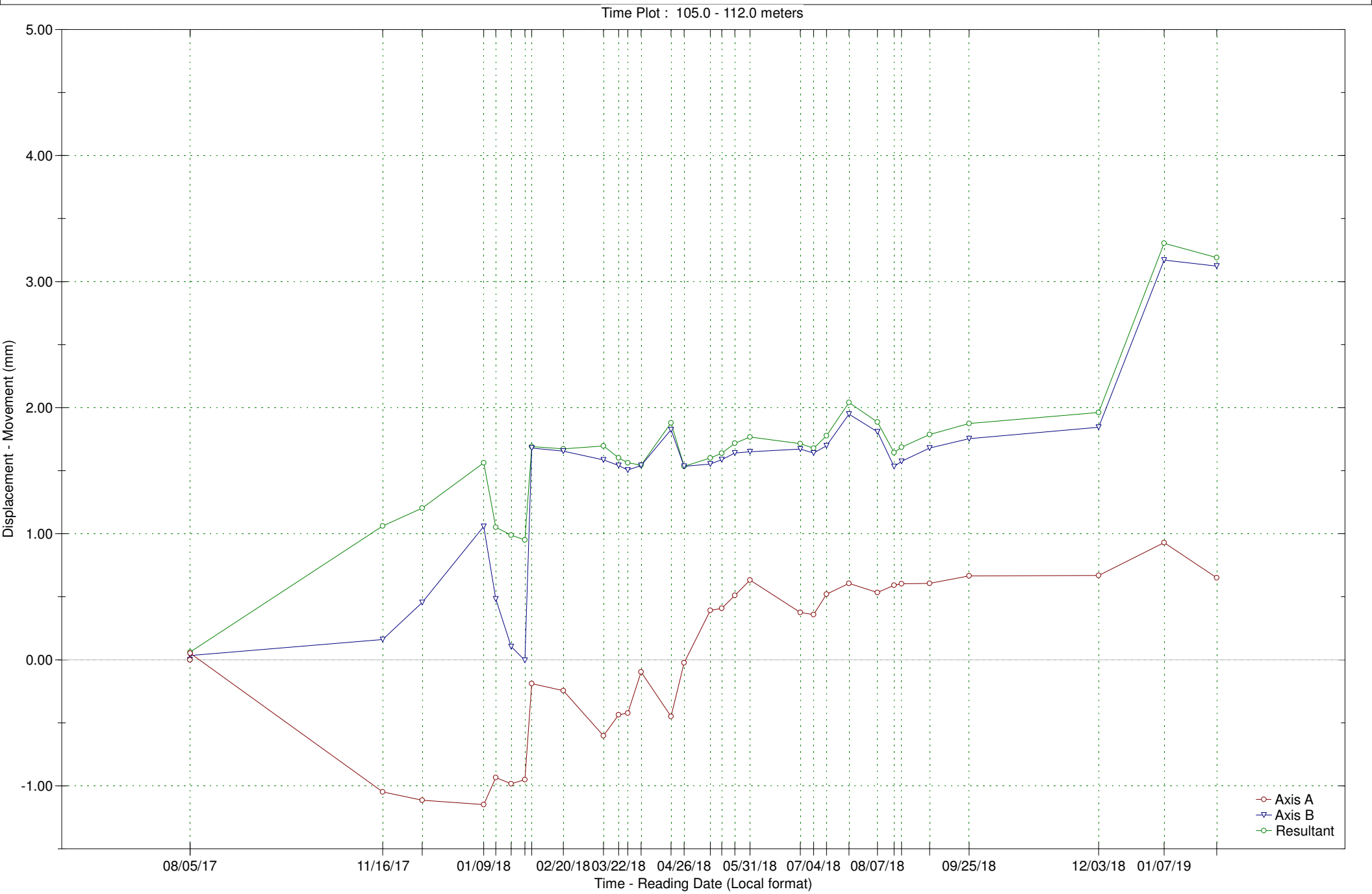
TIME PLOT

Displacement vs. Time

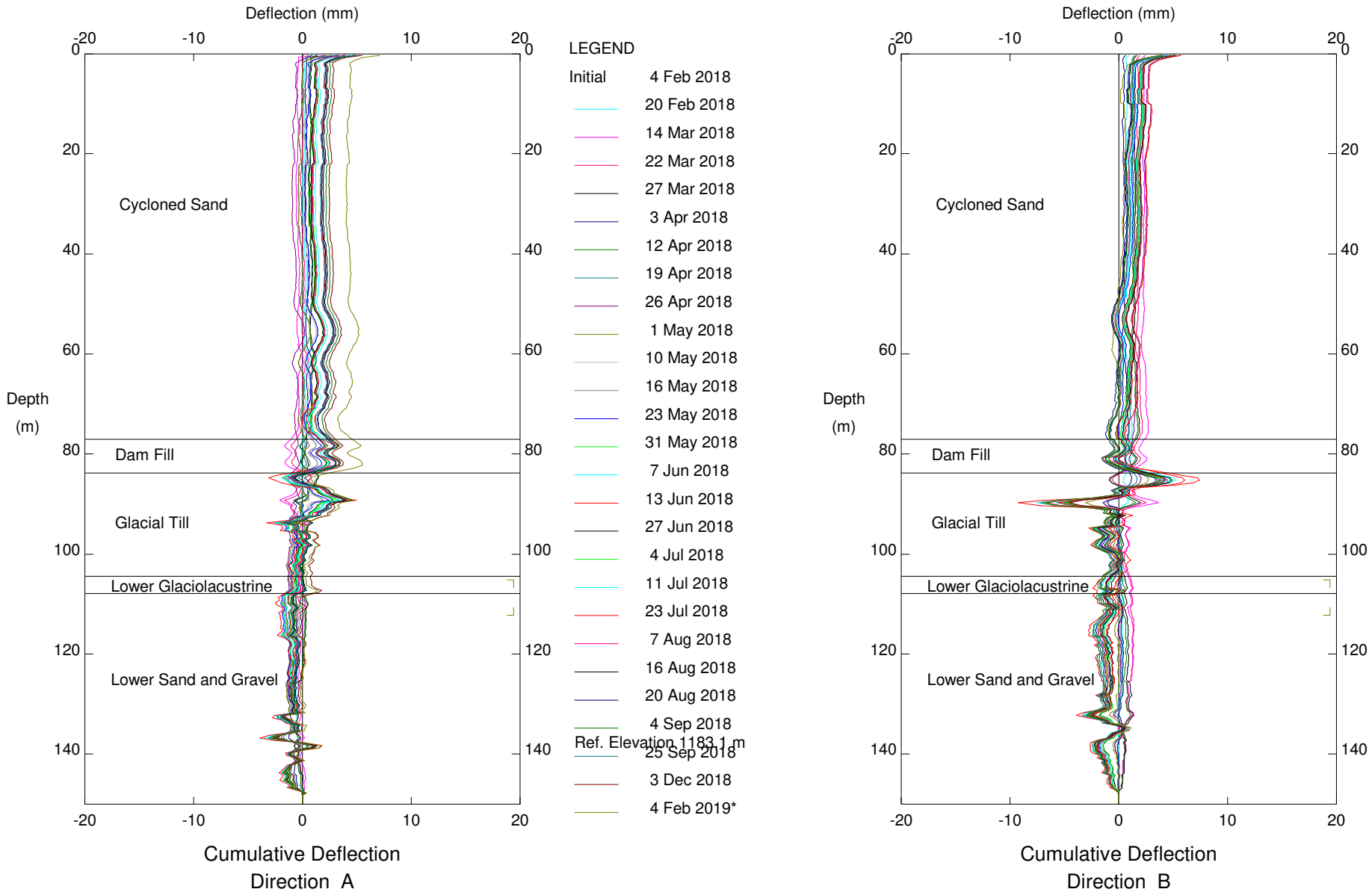
Inclinalysis v. 2.48.7

Borehole : I17-09
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1183.10 meters

Spiral Correction : N/A
Movement Depth : 105.0 - 112.0 meters
Reading Depth : 149.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 04 13:47
Initial Reading : 2017 Aug 05 20:11
Applied Azimuth : 0.0 degrees



Highland Valley Copper - Logan Lake, BC

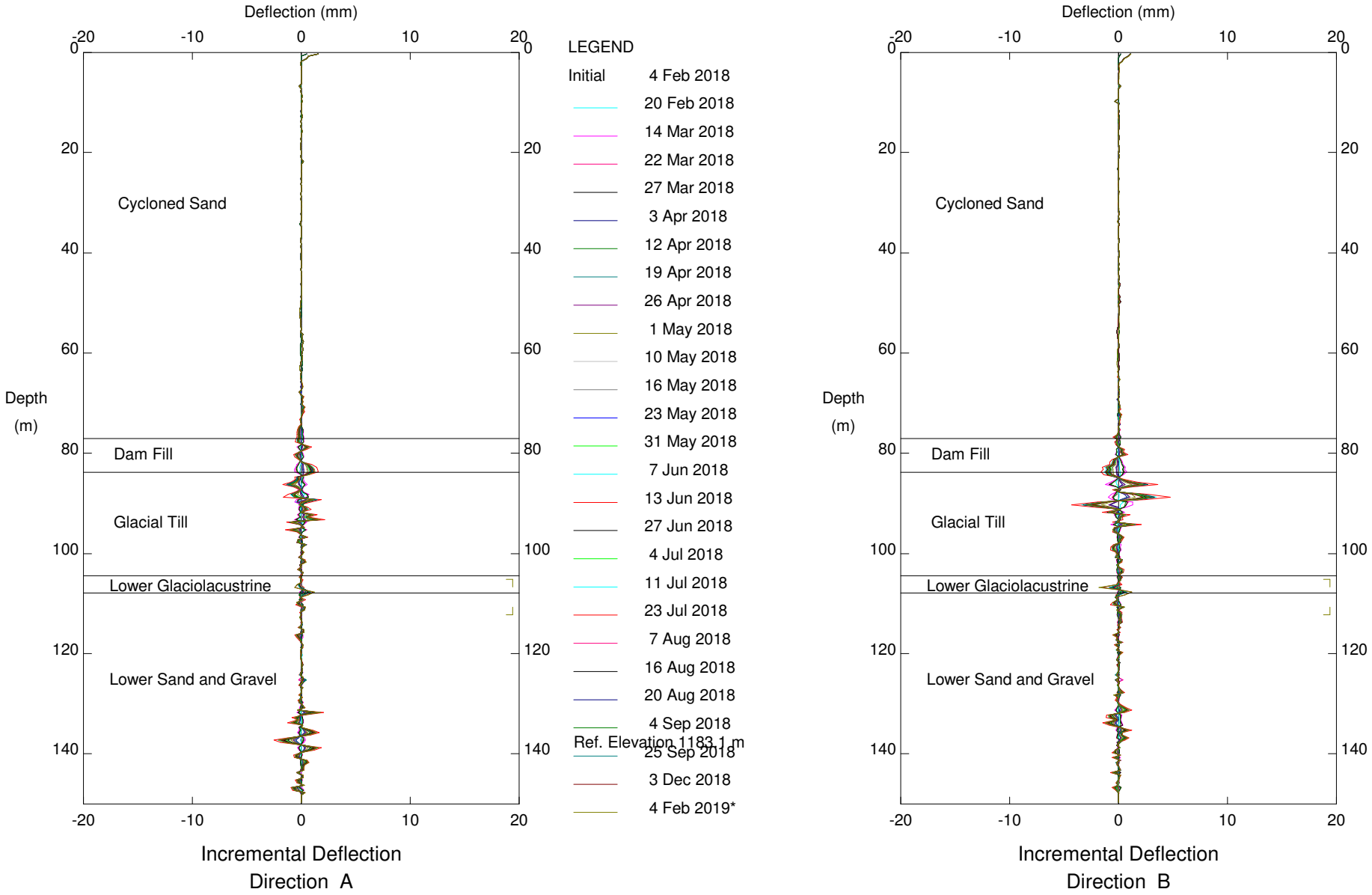


LL Dam, Inclinometer I17-9

Sets marked * include zero shift and/or rotation corrections.

V:\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\L-L Dam\SI Monitoring\Inclinalysis Files\1----Including dam fill\I17-09\GTILT\I17-9.gtl

Highland Valley Copper - Logan Lake, BC

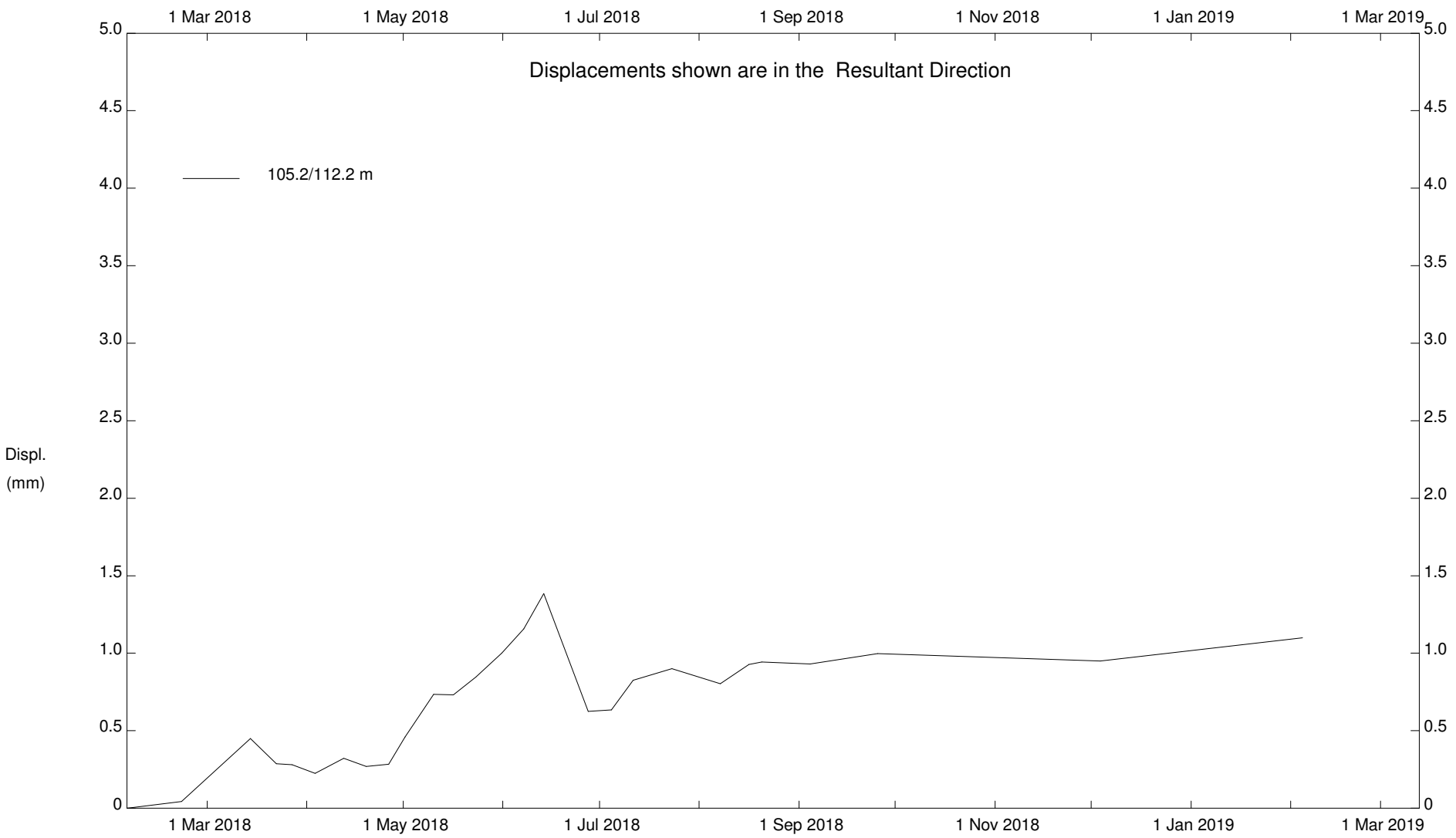


LL Dam, Inclinometer I17-9

Sets marked * include zero shift and/or rotation corrections.

V:\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\L-L Dam\SI Monitoring\Inclinalysis Files\1----Including dam fill\I17-09\GTILT\I17-9.gtl

Highland Valley Copper - Logan Lake, BC



LL Dam, Inclinometer I17-9

VALLEY BUTTRESS BERM

I17-10

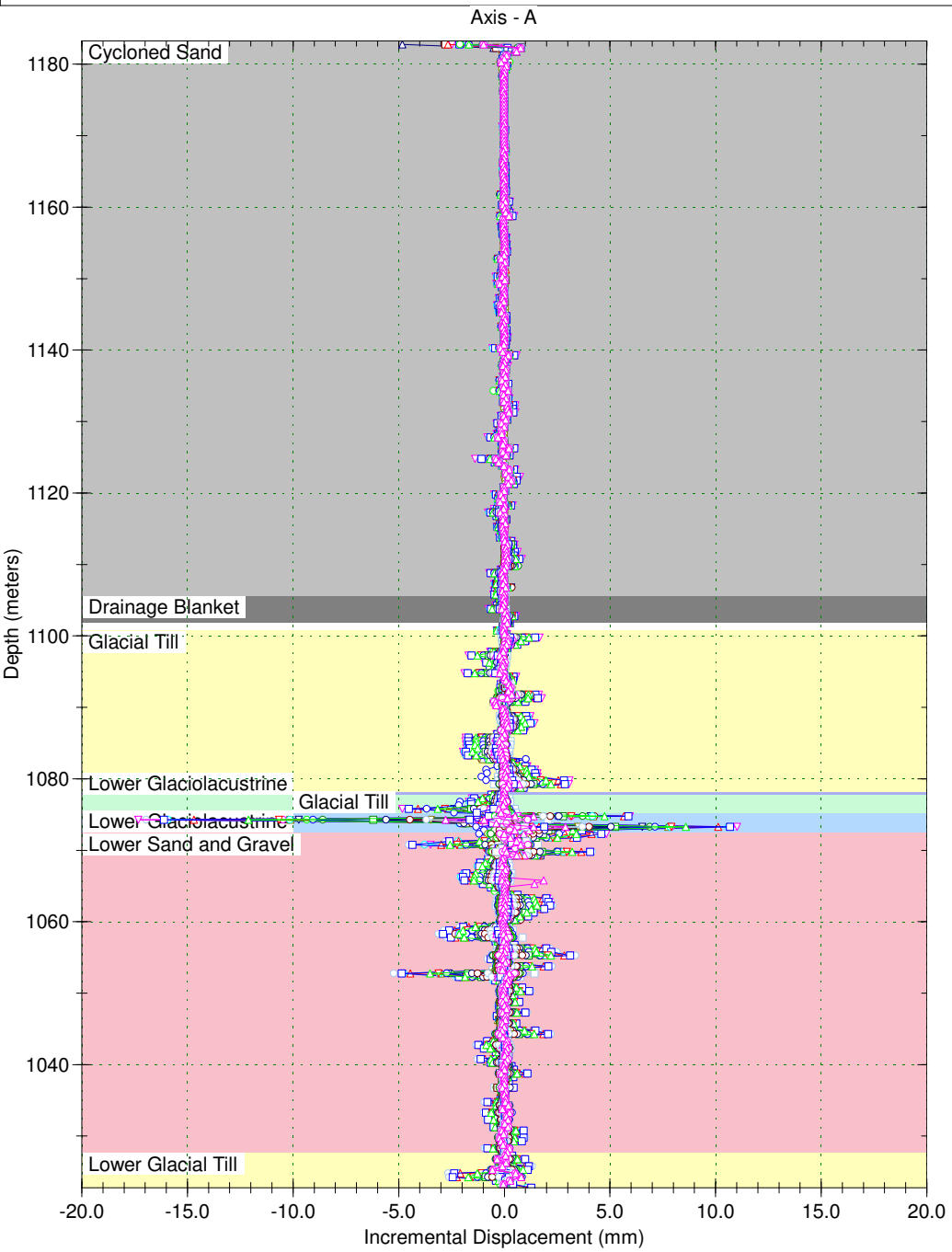
RST Instruments Ltd.

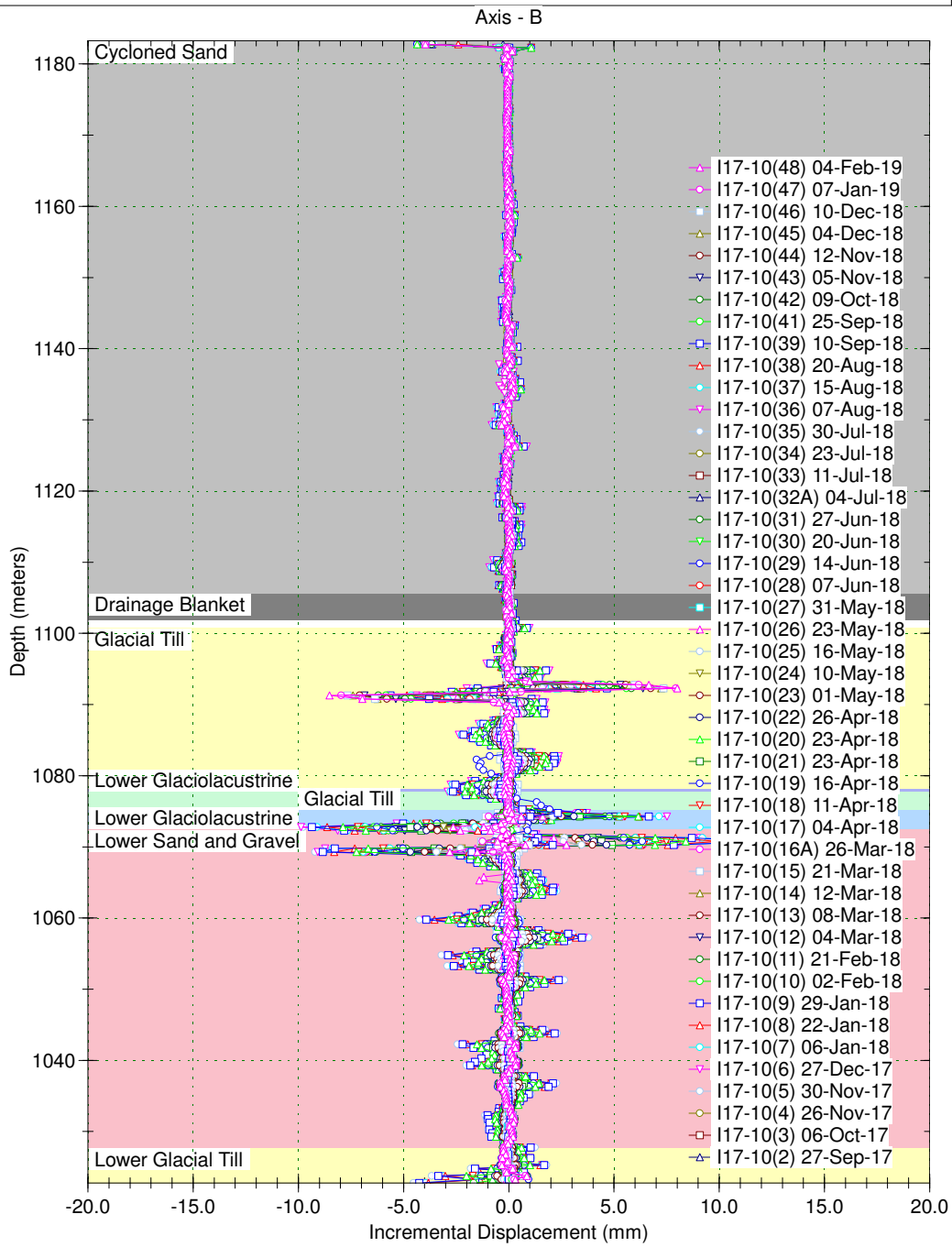
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I17-10
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : Enabled
Collar Elevation : :1183.27 meters
Reading Depth : 160.5 meters
A+ Groove Azimuth :
Base Reading : 2017 Sep 27 11:18
Applied Azimuth : 0.0 degrees





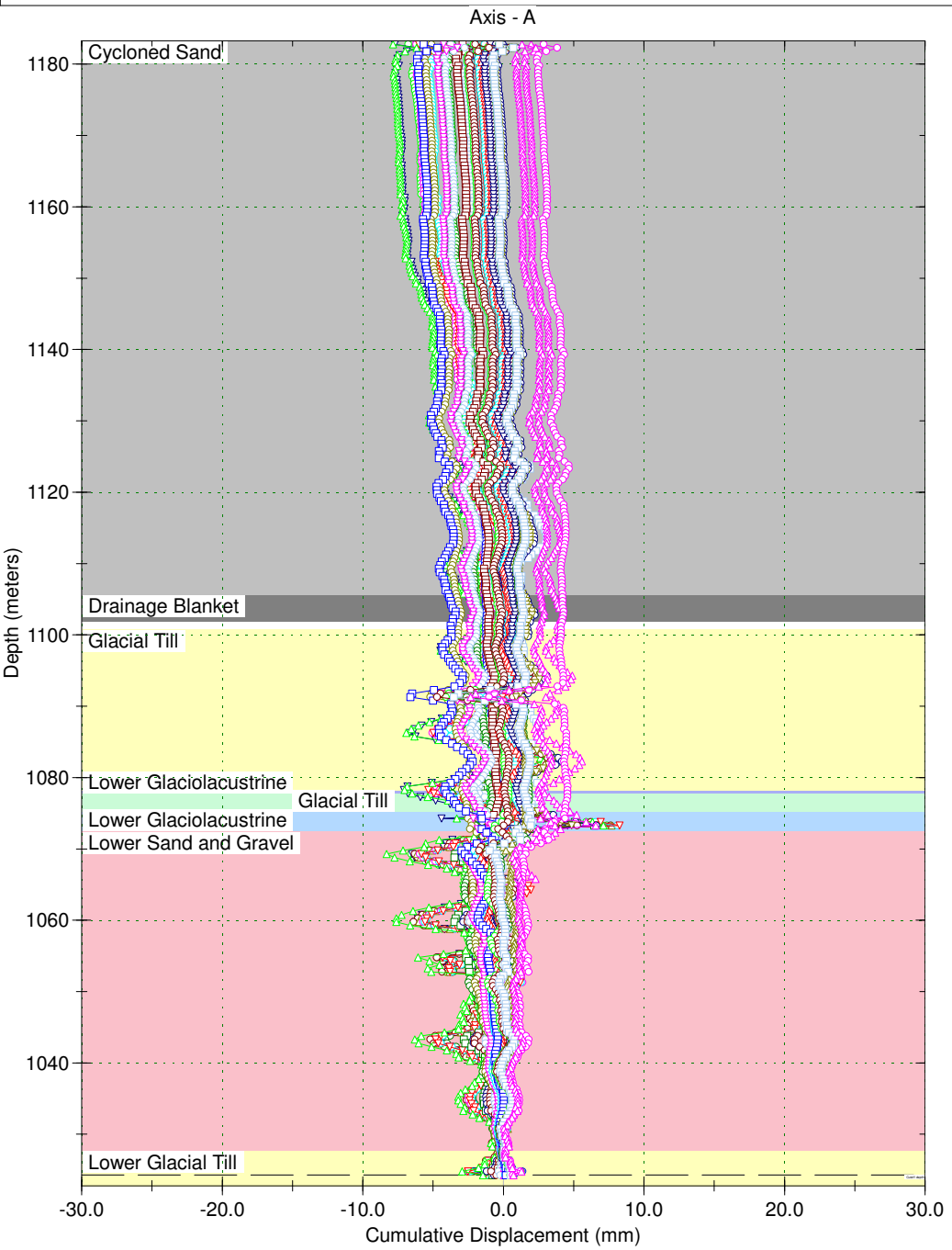
RST Instruments Ltd.

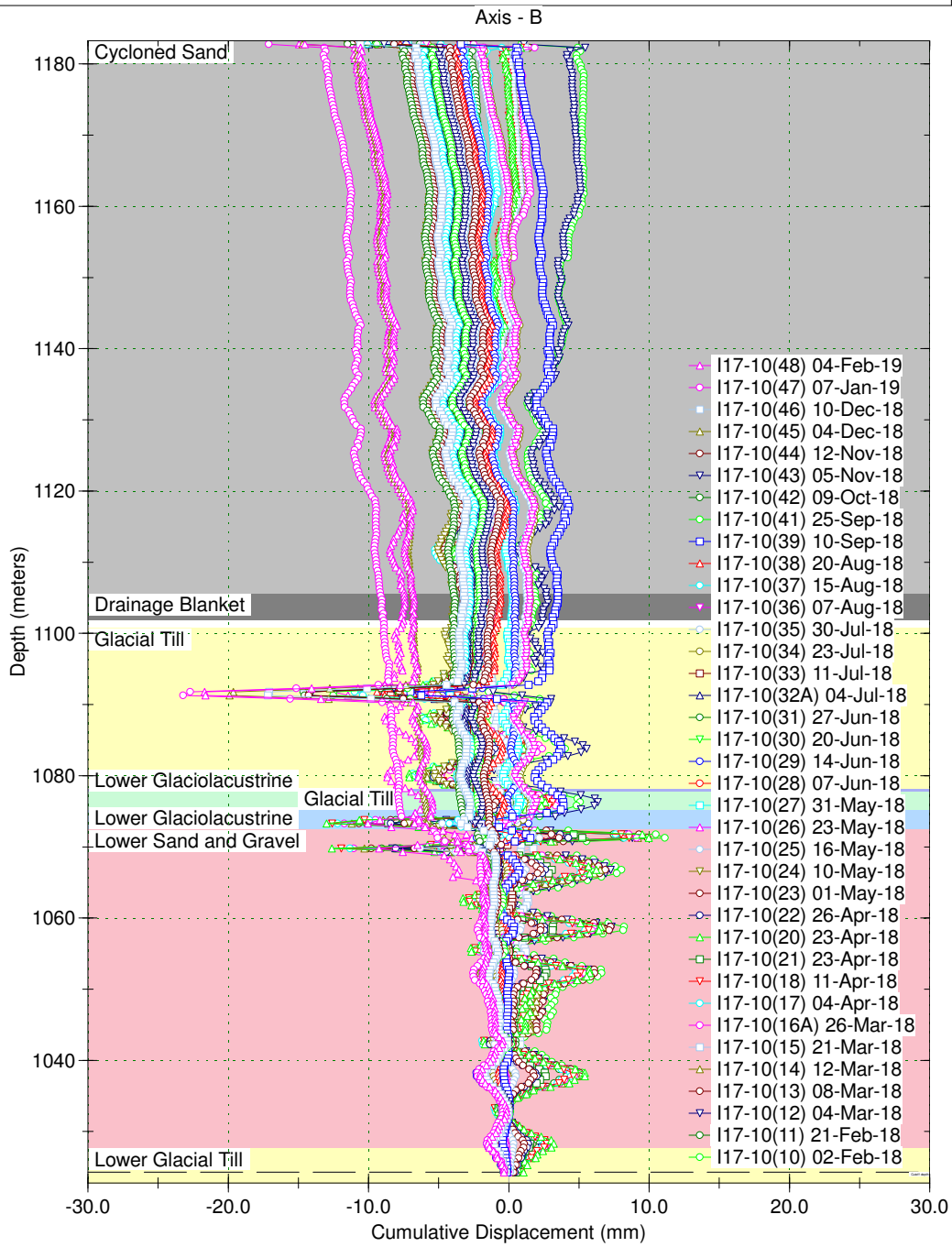
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I17-10
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1183.27 meters
Reading Depth : 160.5 meters
A+ Groove Azimuth :
Base Reading :
Applied Azimuth : 0.0 degrees





RST Instruments Ltd.

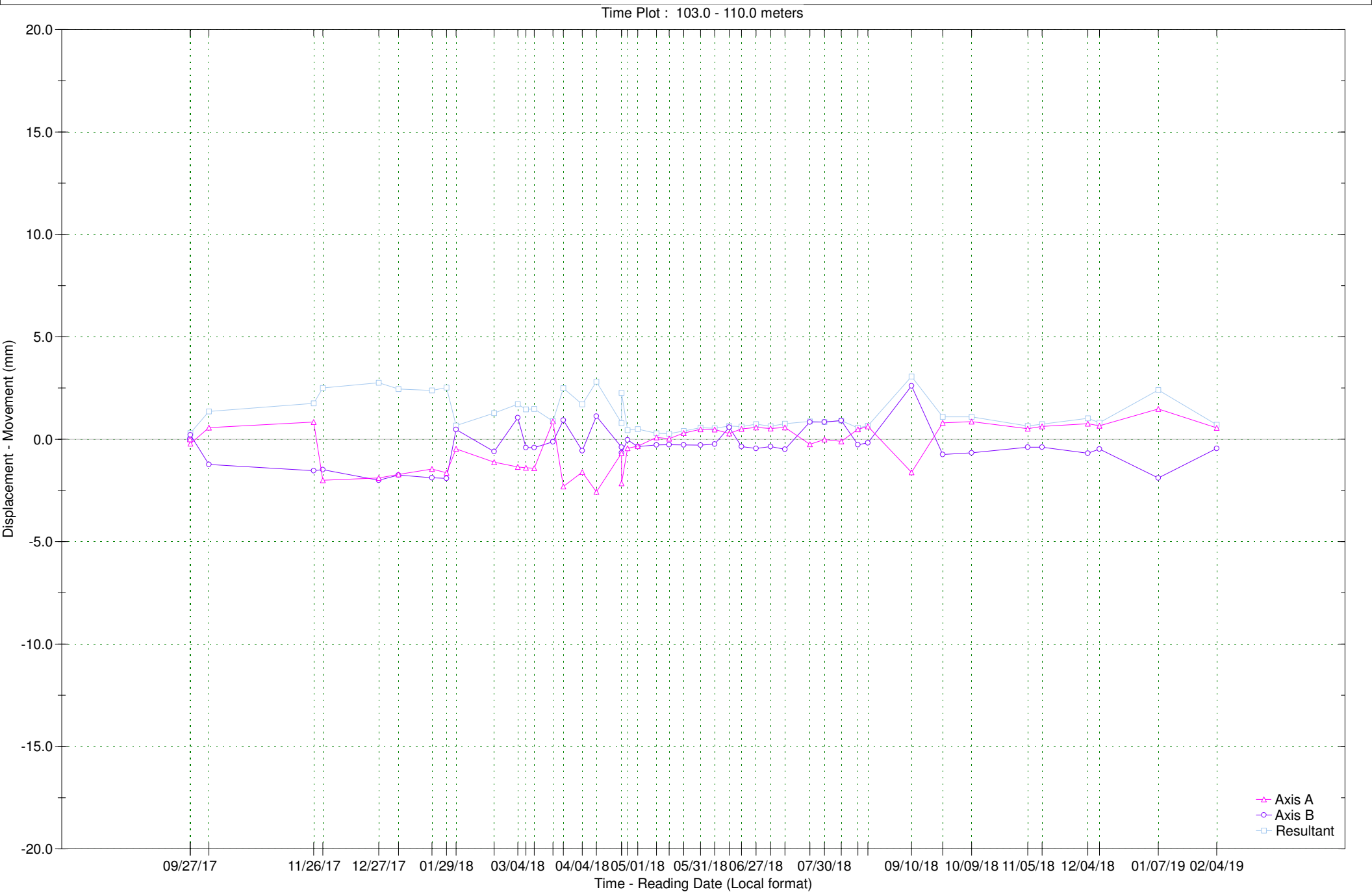
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I17-10
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1183.27 meters

Spiral Correction : N/A
Movement Depth : 103.0 - 110.0 meters
Reading Depth : 159.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 04 14:57
Initial Reading : 2017 Sep 27 11:18
Applied Azimuth : 0.0 degrees



VALLEY BUTTRESS BERM

I17-11

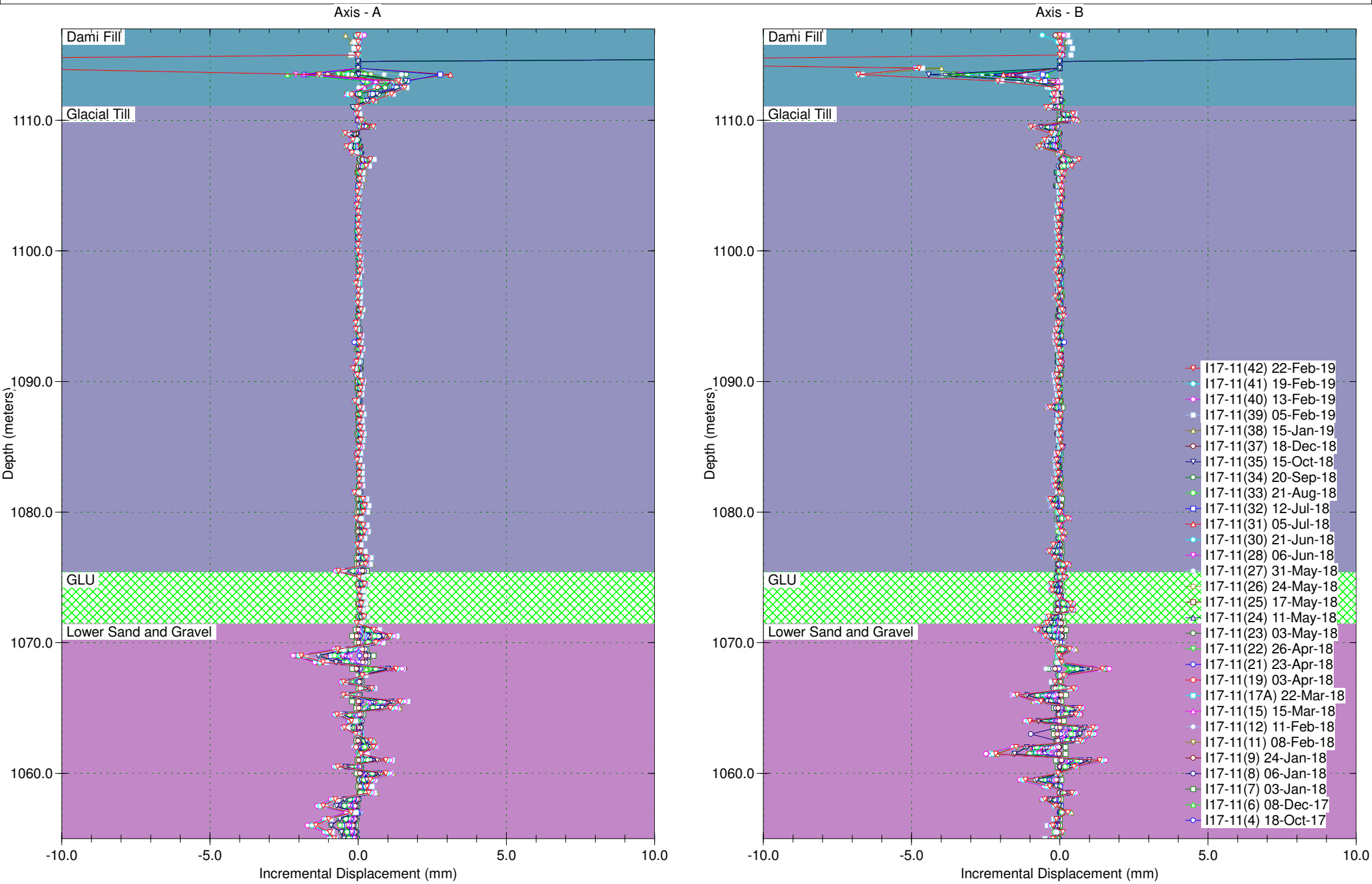
RST Instruments Ltd.

INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-11
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1117.00 meters
Reading Depth : 62.0 meters
A+ Groove Azimuth :
Base Reading : 2017 Sep 27 11:12
Applied Azimuth : 0.0 degrees



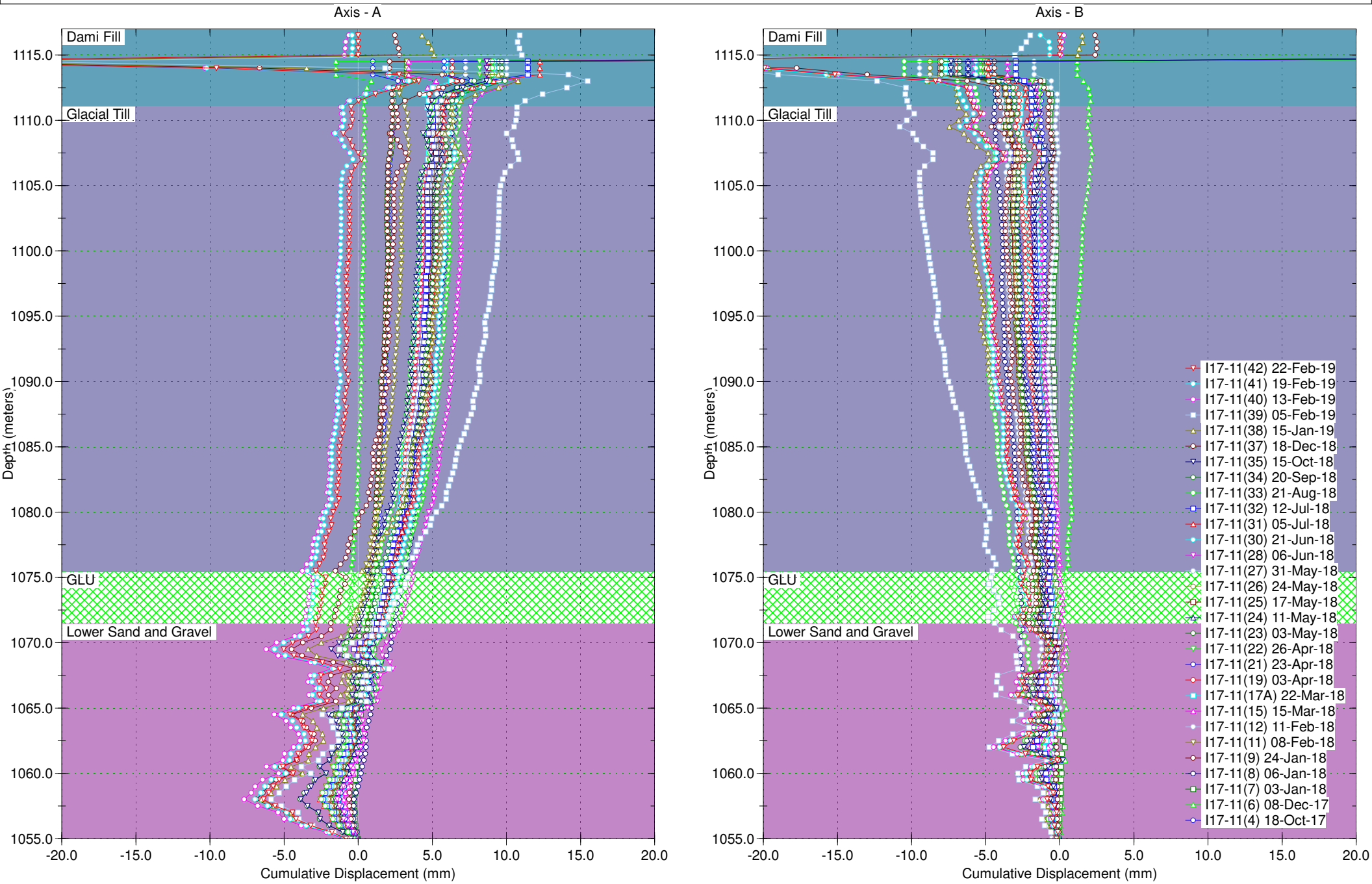
RST Instruments Ltd.

CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-11
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1117.00 meters
Reading Depth : 62.0 meters
A+ Groove Azimuth :
Base Reading : 2017 Sep 27 11:12
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

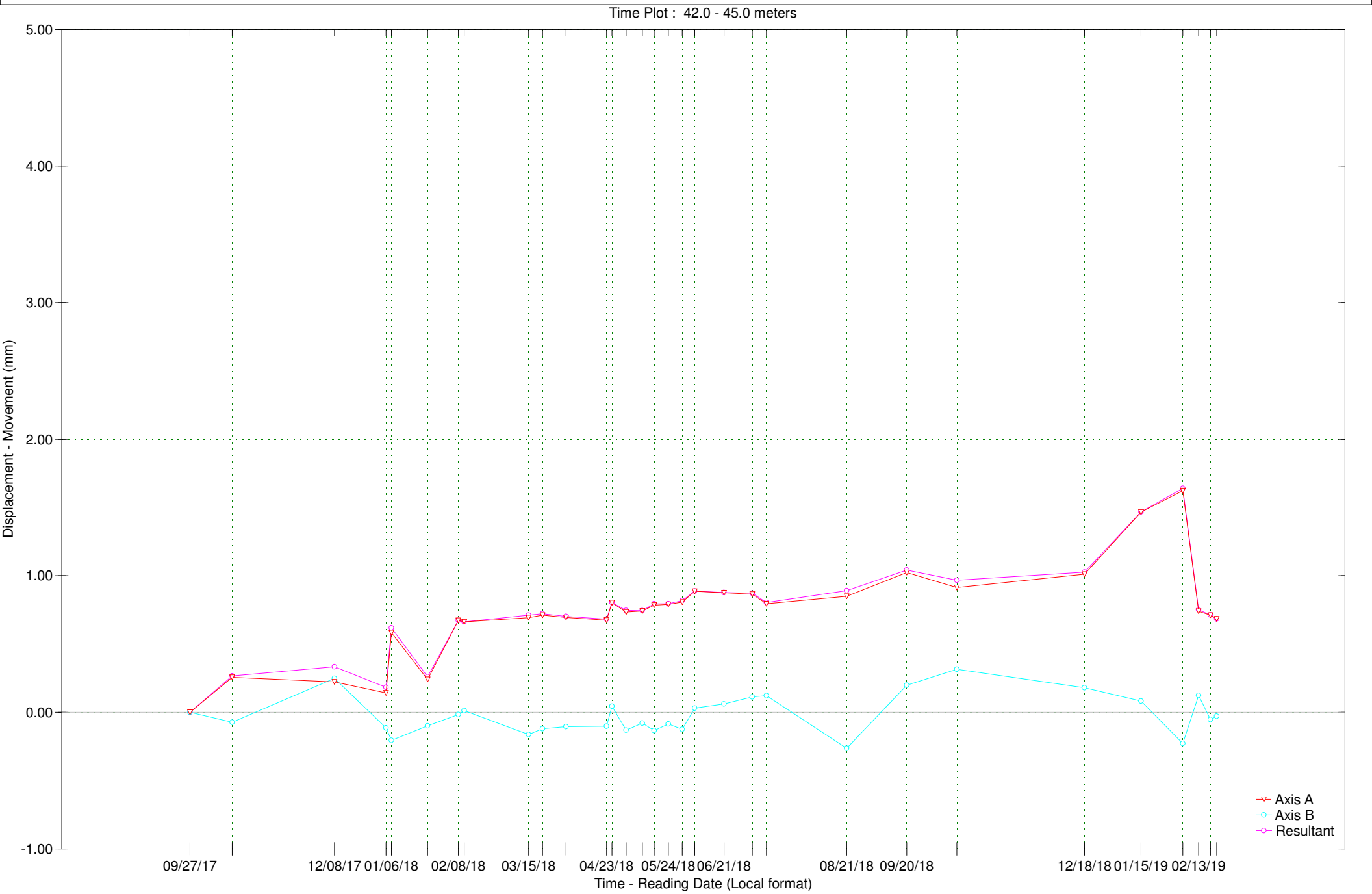
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-11
Location :
Northing :
Easting :
Collar :
Collar Elev : 1117.00 meters

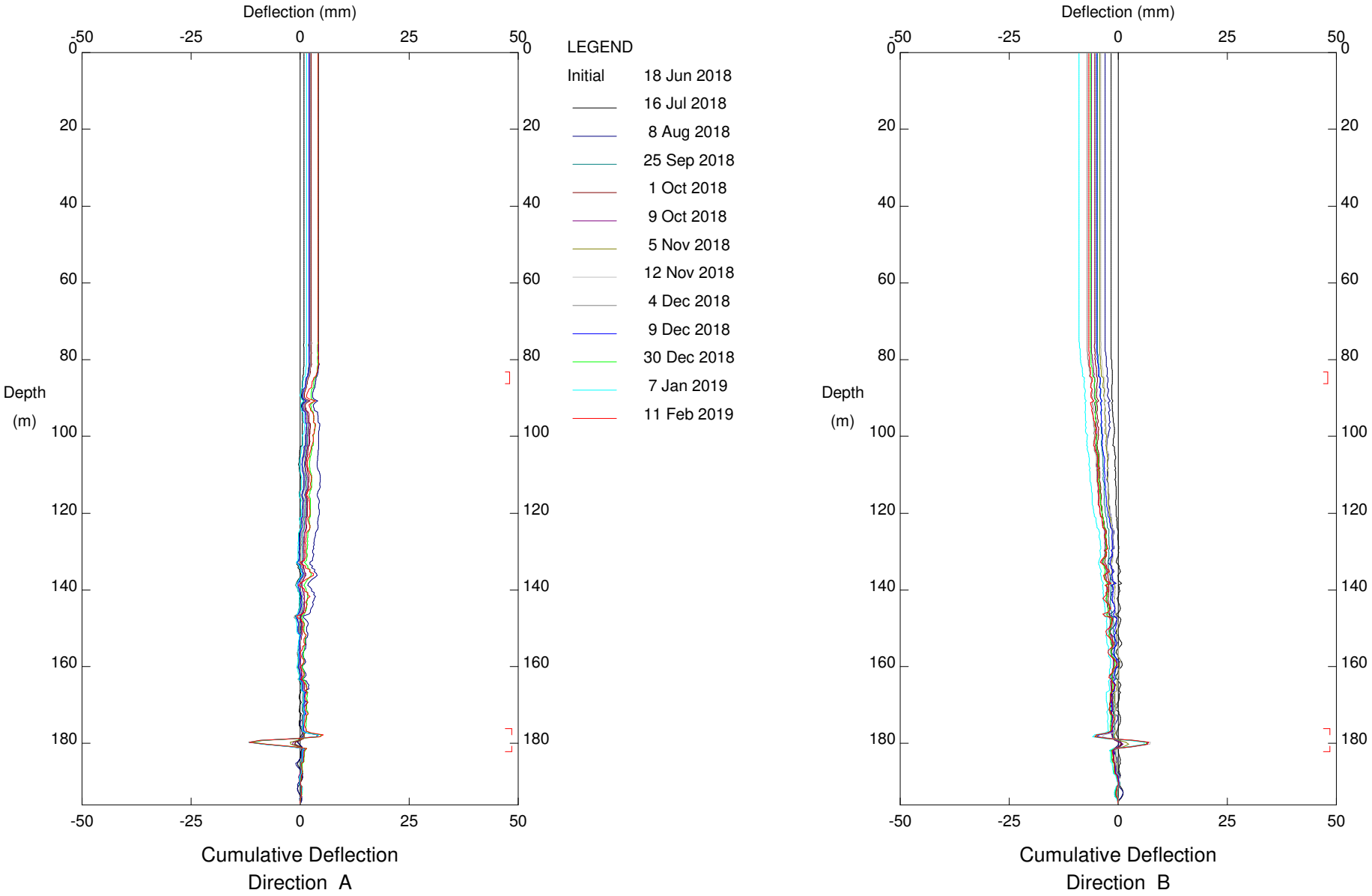
Spiral Correction : N/A
Movement Depth : 42.0 - 45.0 meters
Reading Depth : 62.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 22 10:36
Initial Reading : 2017 Sep 27 11:12
Applied Azimuth : 0.0 degrees



VALLEY BUTTRESS BERM

I17-19

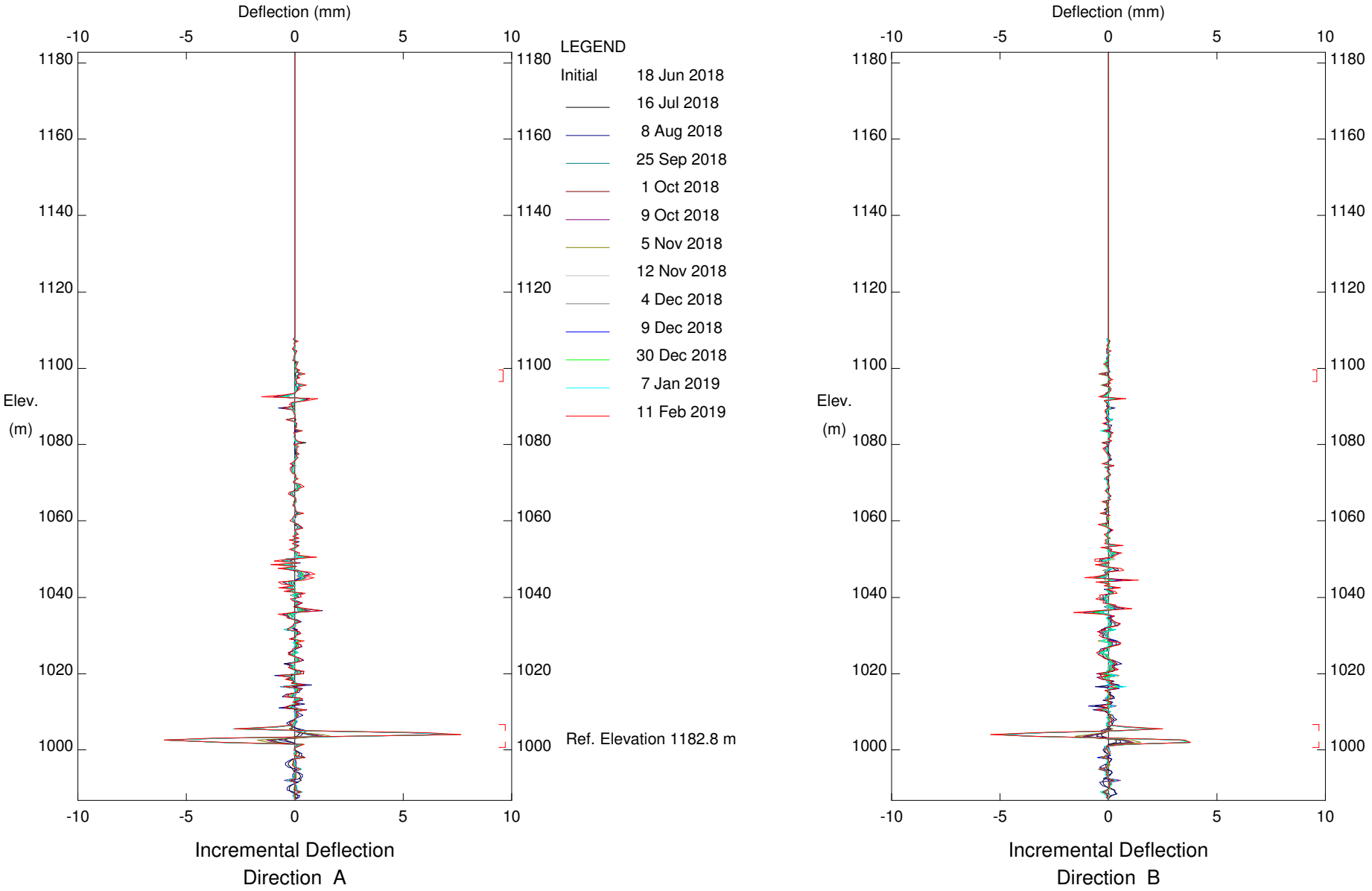
Highland Valley Copper - Logan Lake, BC



Valley Buttress Berm, Inclinometer I17-19

V:\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\L-L Dam\SI Monitoring\Inclinalysis Files\1----Including dam fill\I17-19\GTILT\I17-19.gtl

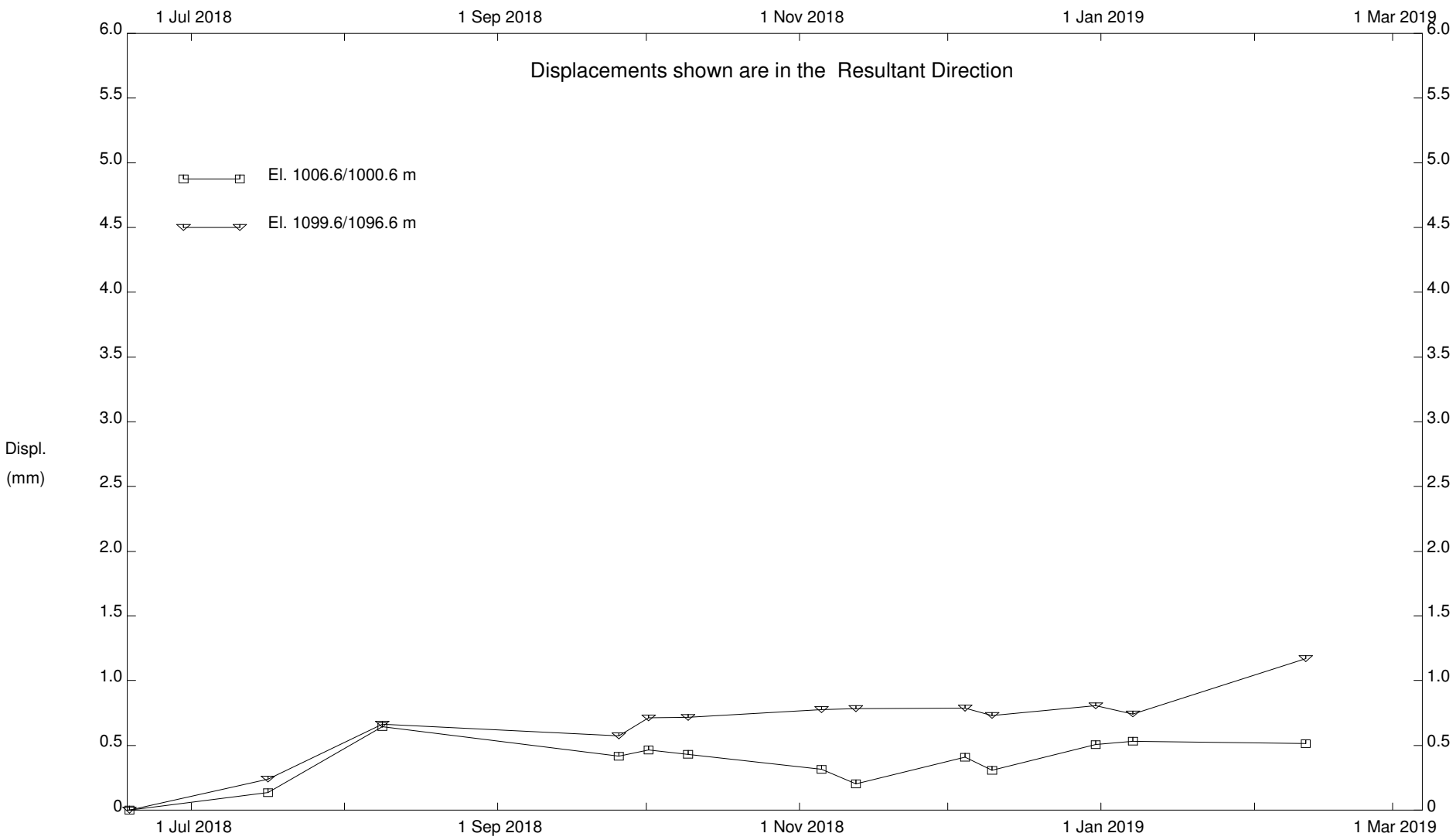
Highland Valley Copper - Logan Lake, BC



Valley Buttress Berm, Inclinometer I17-19

V:\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\L-L Dam\SI Monitoring\Inclinalysis Files\1----Including dam fill\I17-19\GTILT\I17-19.gtl

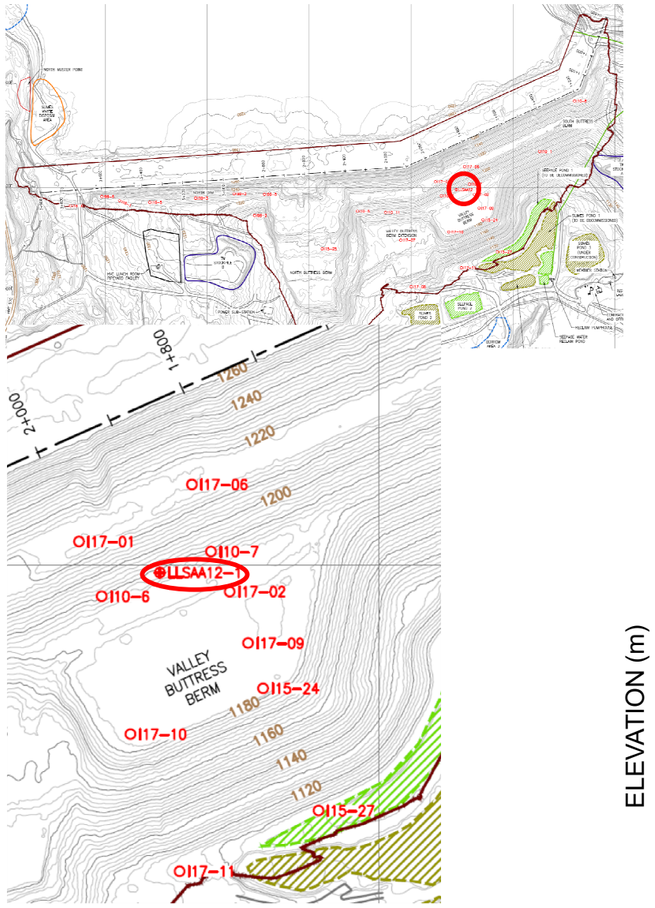
Highland Valley Copper - Logan Lake, BC



Valley Buttress Berm, Inclinometer I17-19

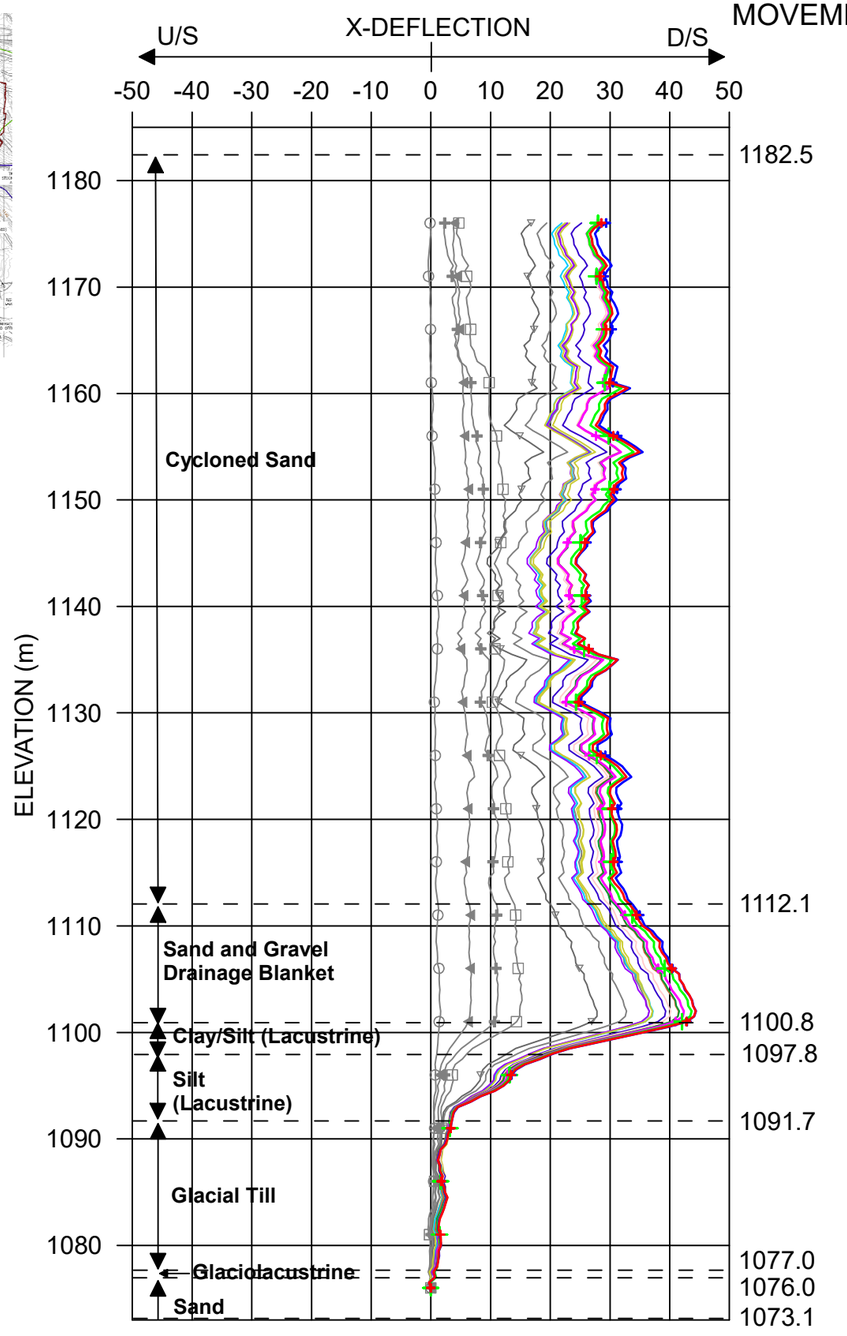
VALLEY BUTTRESS BERM

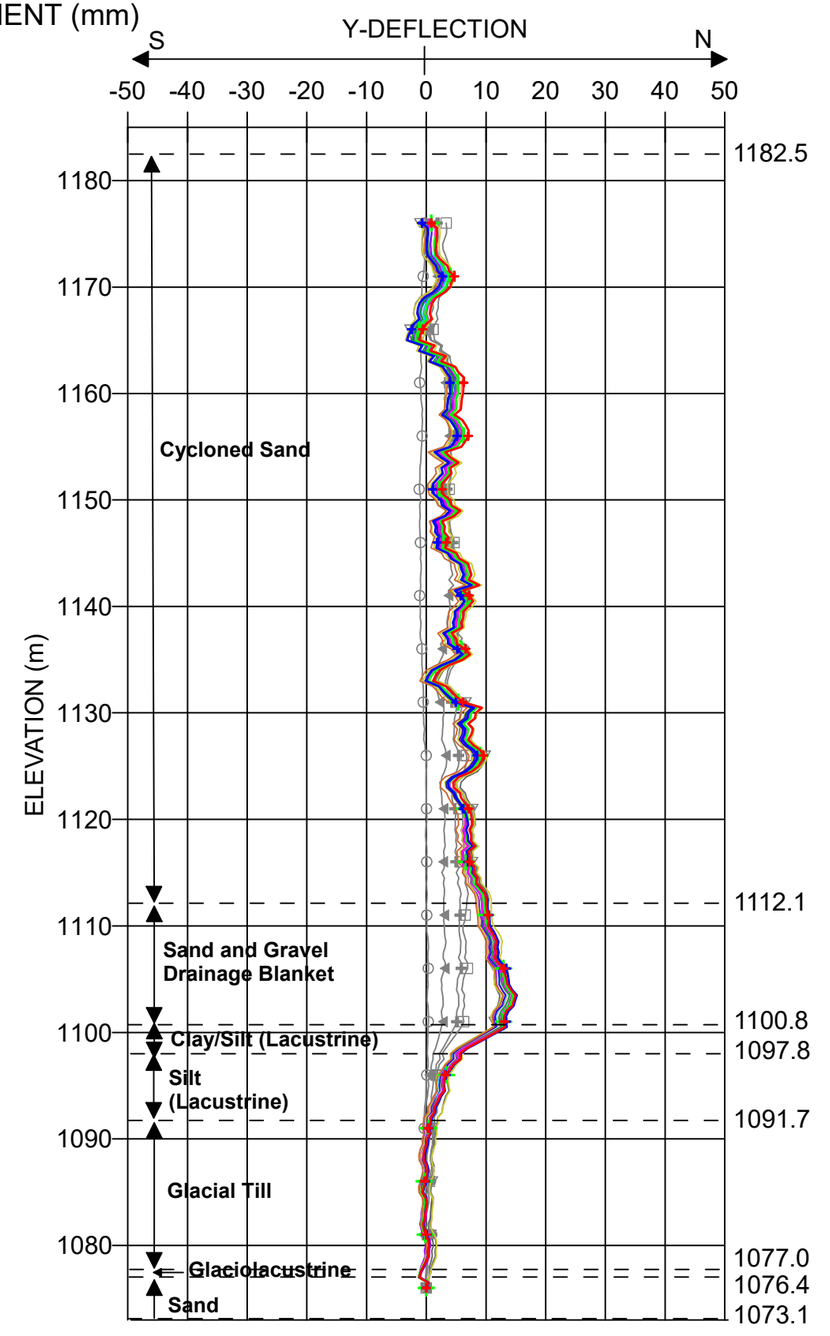
LLSAA12-1



LEGEND

- Oct 30, 2012
- Aug 31, 2013
- Aug 21, 2014
- June 5, 2015
- Jun 16, 2016
- June 7, 2017
- Dec 4, 2017
- Jan 7, 2018
- Feb 24, 2018
- Mar 19, 2018
- Apr 27, 2018
- Jun 27, 2018
- Jul 27, 2018
- Aug 27, 2018
- Sep 21, 2018
- Oct 17, 2018
- Nov 12, 2018
- Dec 11, 2018
- Jan 01, 2019





NOTES:

1) SAA installed on May 23, 2012.
2) SAA re-initialized on September 12, 2012 to eliminate early erroneous data.
3) Not all readings are plotted.

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

TITLE
INCLINOMETER CUMULATIVE DISPLACEMENT PROFILE
LLSAA12-1

PROJECT No. M02341B43

FIG No.

Date: March 22, 2019
\\int.klohn.com\ProjData\MVCR\M02341B43 - HVC 2018 Dam Safety Support\300 Design\Inclinometer Data\Inclinometer processing\L-L Dam\LLSAA12-1\LLSAA12-1 2018 (DSI Only).grf

SOUTH DAM

I10-01

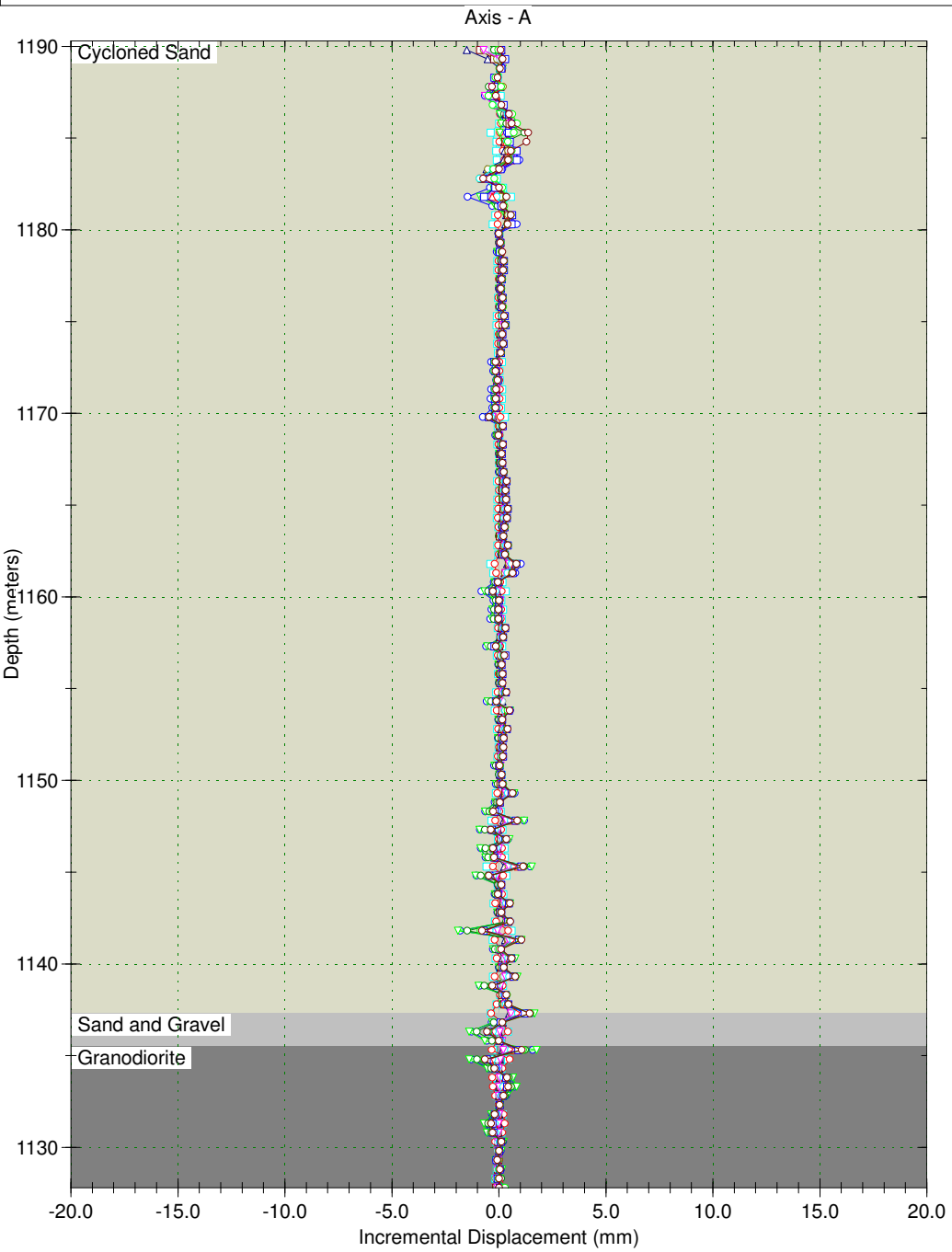
RST Instruments Ltd.

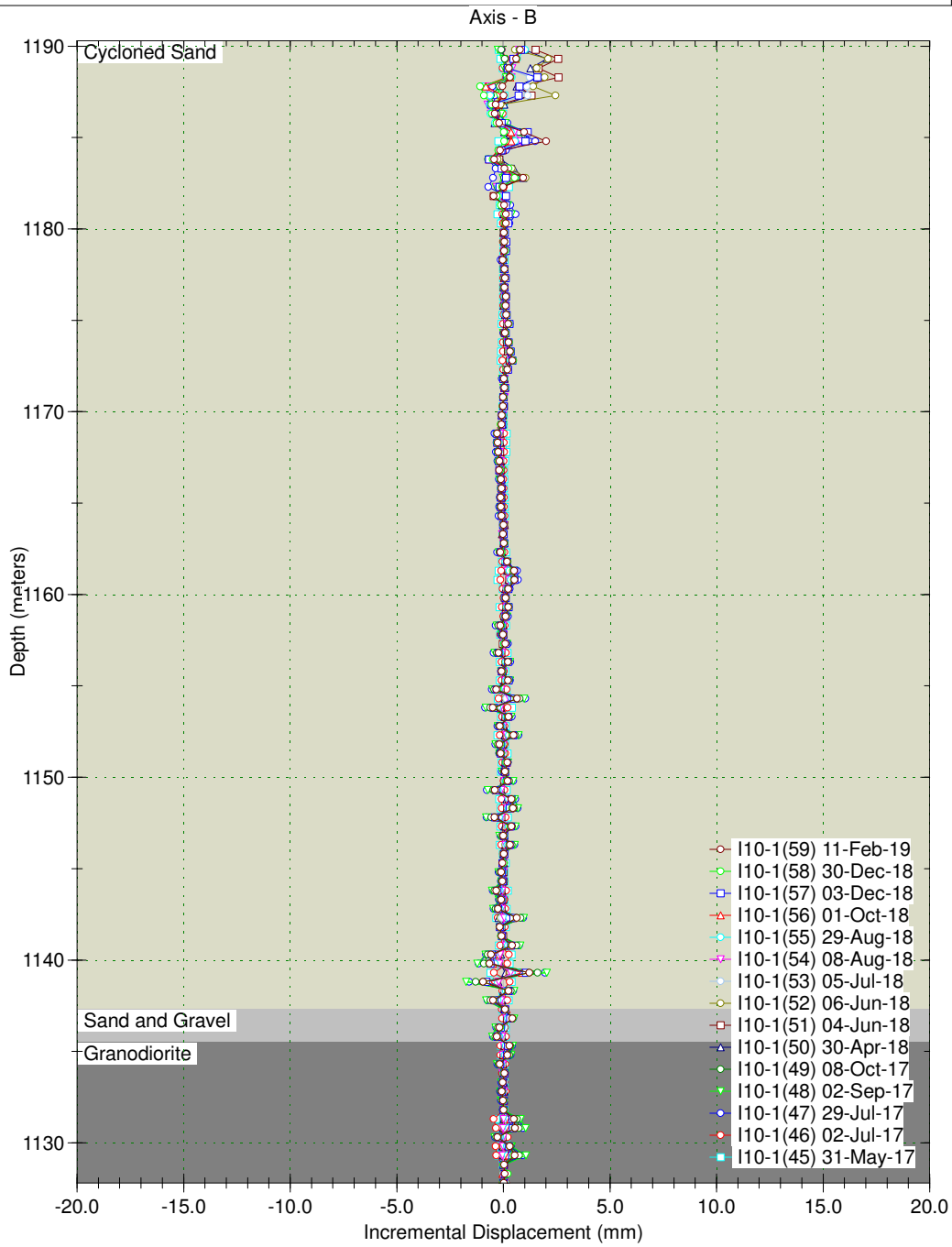
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I10-1
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1190.30 meters
Reading Depth : 62.5 meters
A+ Groove Azimuth :
Base Reading : 2017 Apr 25 17:41
Applied Azimuth : 0.0 degrees





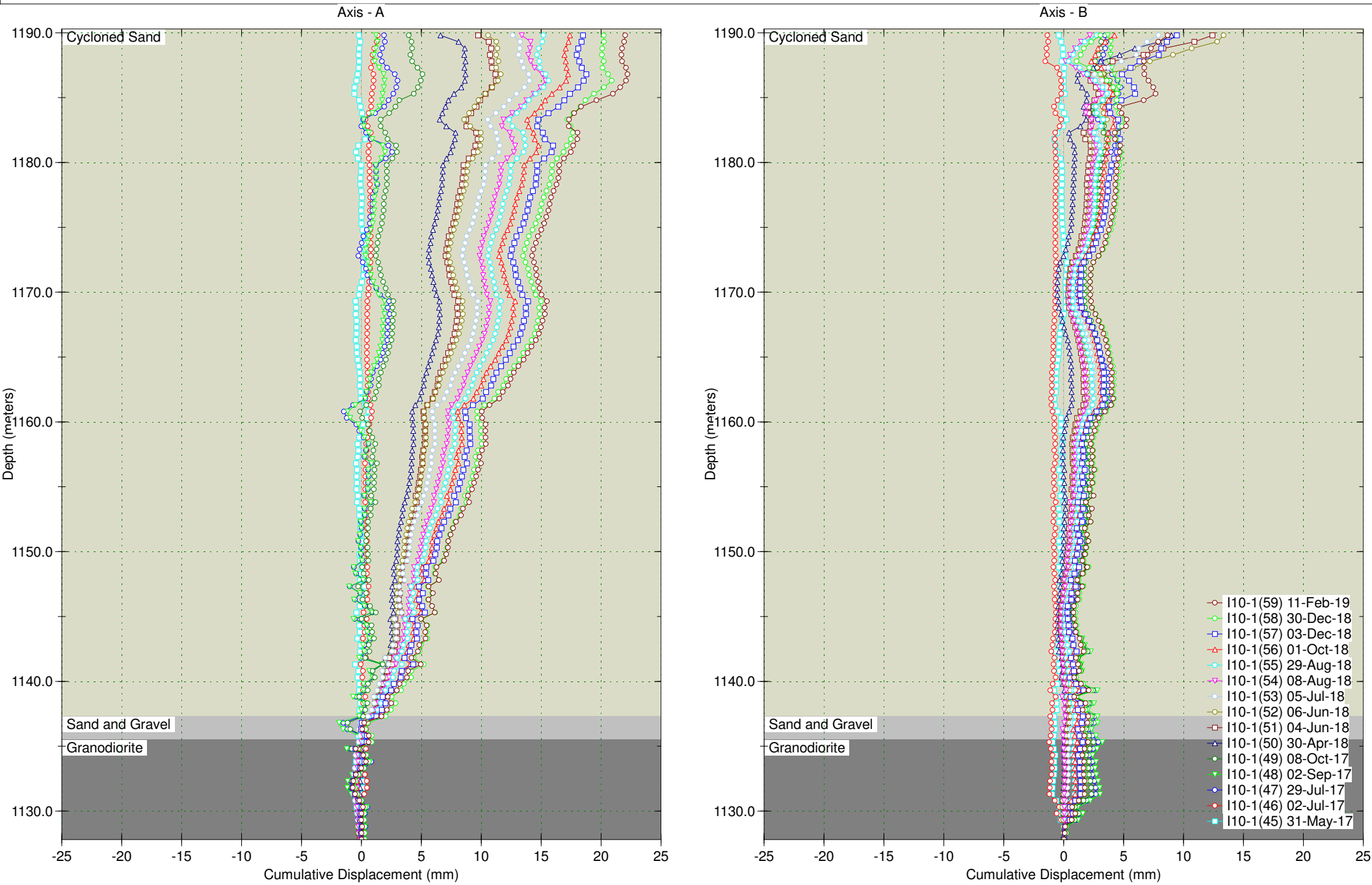
RST Instruments Ltd.

CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I10-1
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1190.30 meters
Reading Depth : 62.5 meters
A+ Groove Azimuth :
Base Reading : 2017 Apr 25 17:41
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

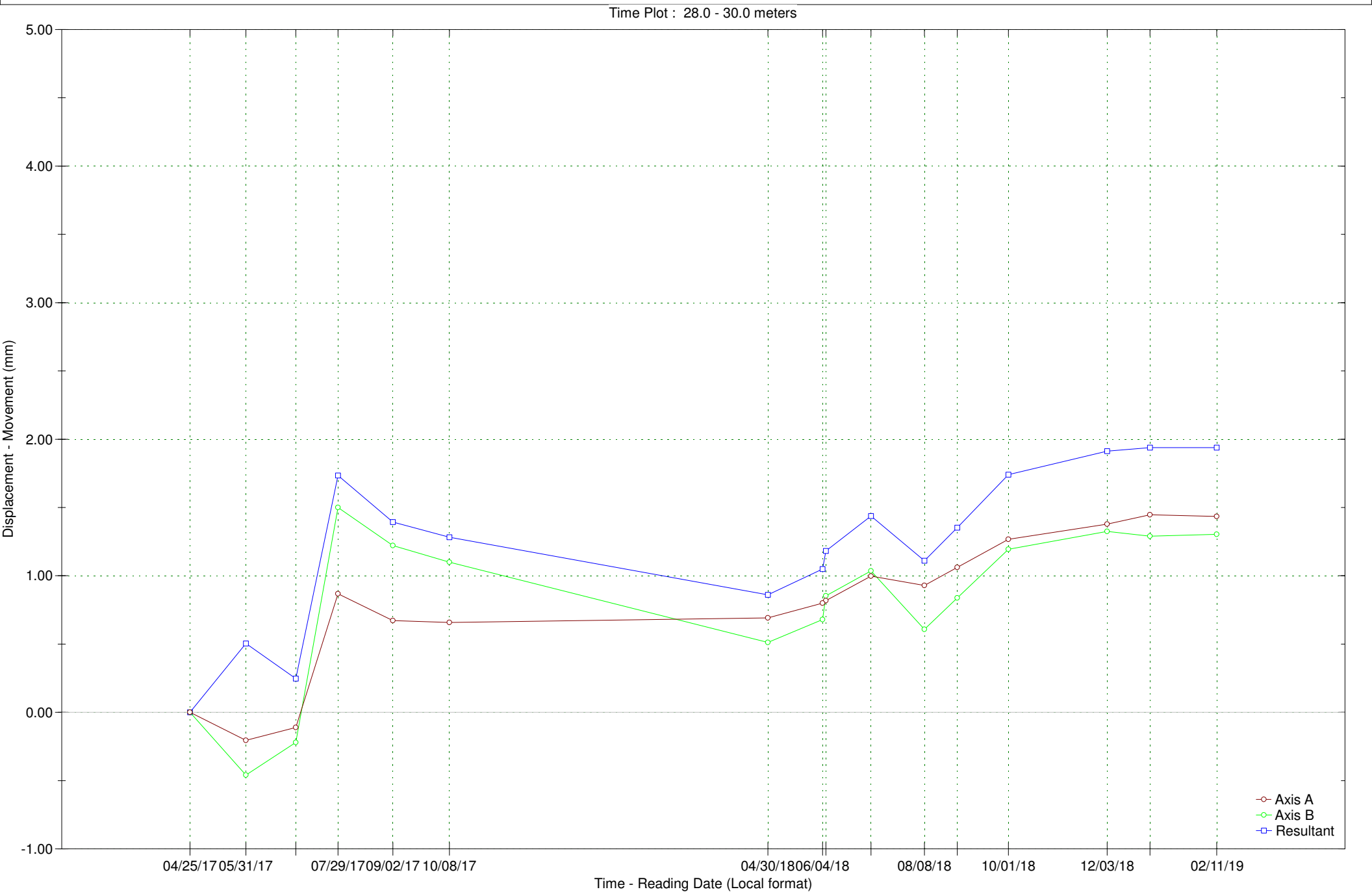
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I10-1
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1190.30 meters

Spiral Correction : N/A
Movement Depth : 28.0 - 30.0 meters
Reading Depth : 62.5 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 11 14:04
Initial Reading : 2017 Apr 25 17:41
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

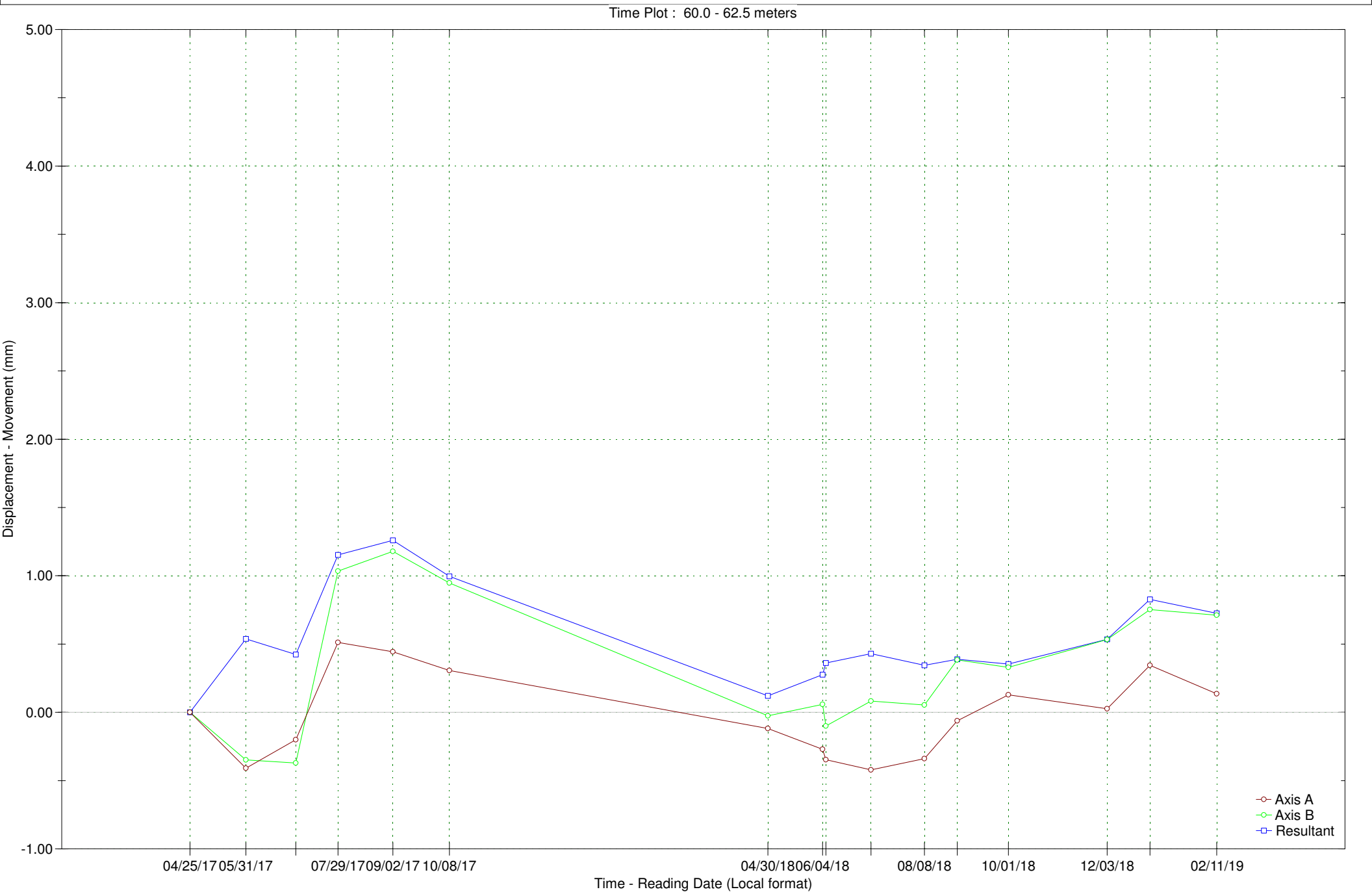
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I10-1
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1190.30 meters

Spiral Correction : N/A
Movement Depth : 60.0 - 62.5 meters
Reading Depth : 62.5 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 11 14:04
Initial Reading : 2017 Apr 25 17:41
Applied Azimuth : 0.0 degrees



SOUTH DAM

I10-08

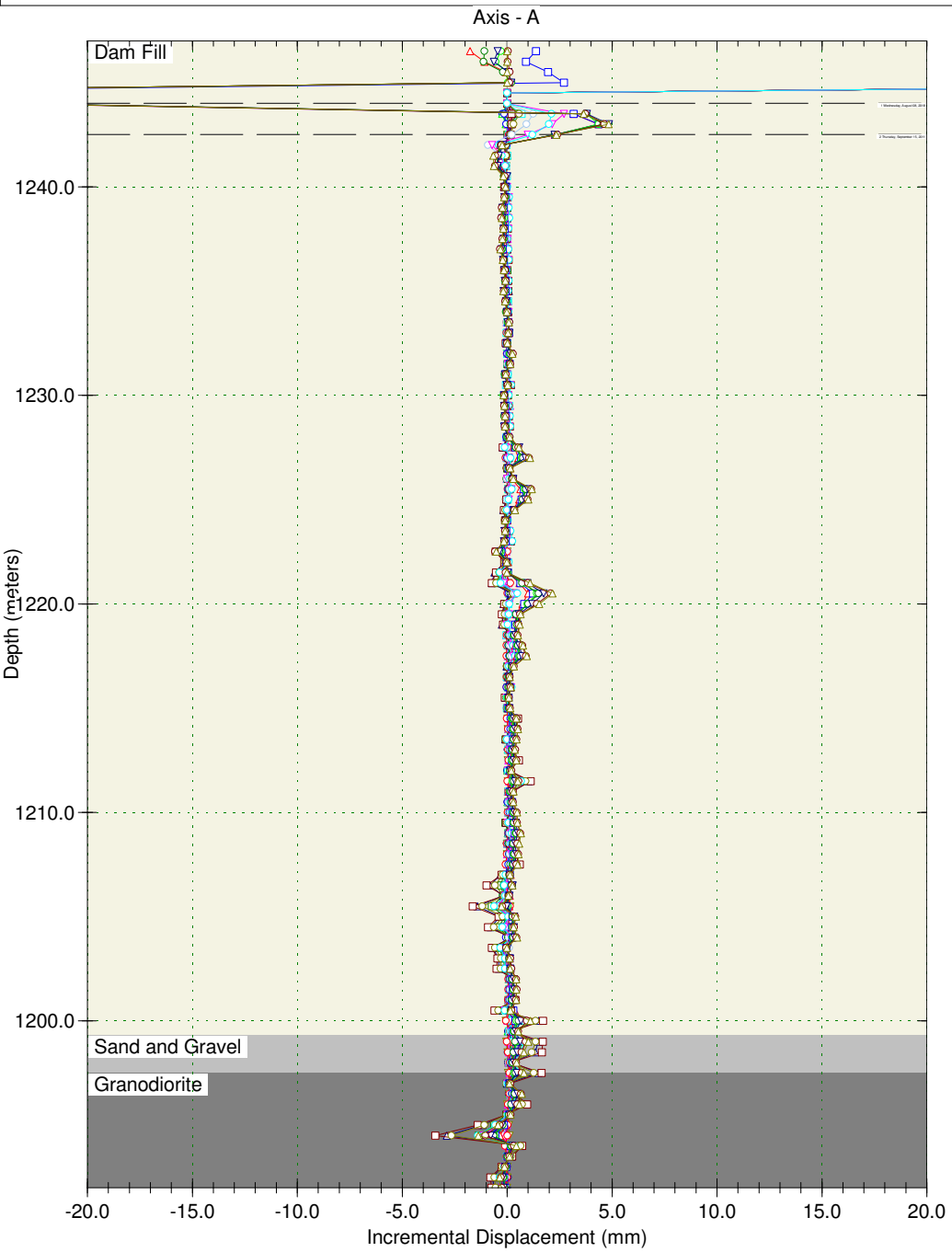
RST Instruments Ltd.

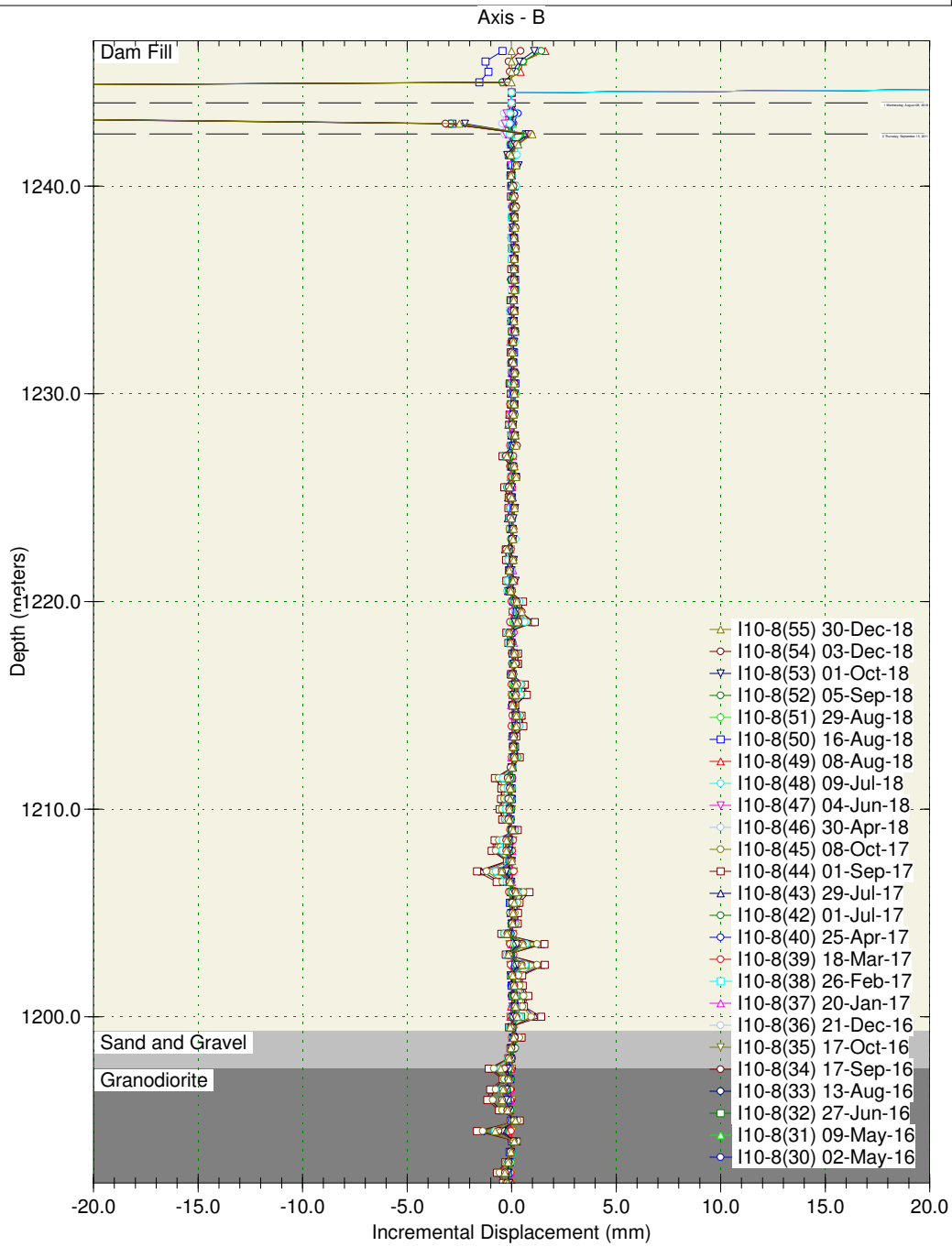
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I10-8
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1247.00 meters
Reading Depth : 55.0 meters
A+ Groove Azimuth :
Base Reading : 2016 Feb 17 13:27
Applied Azimuth : 0.0 degrees





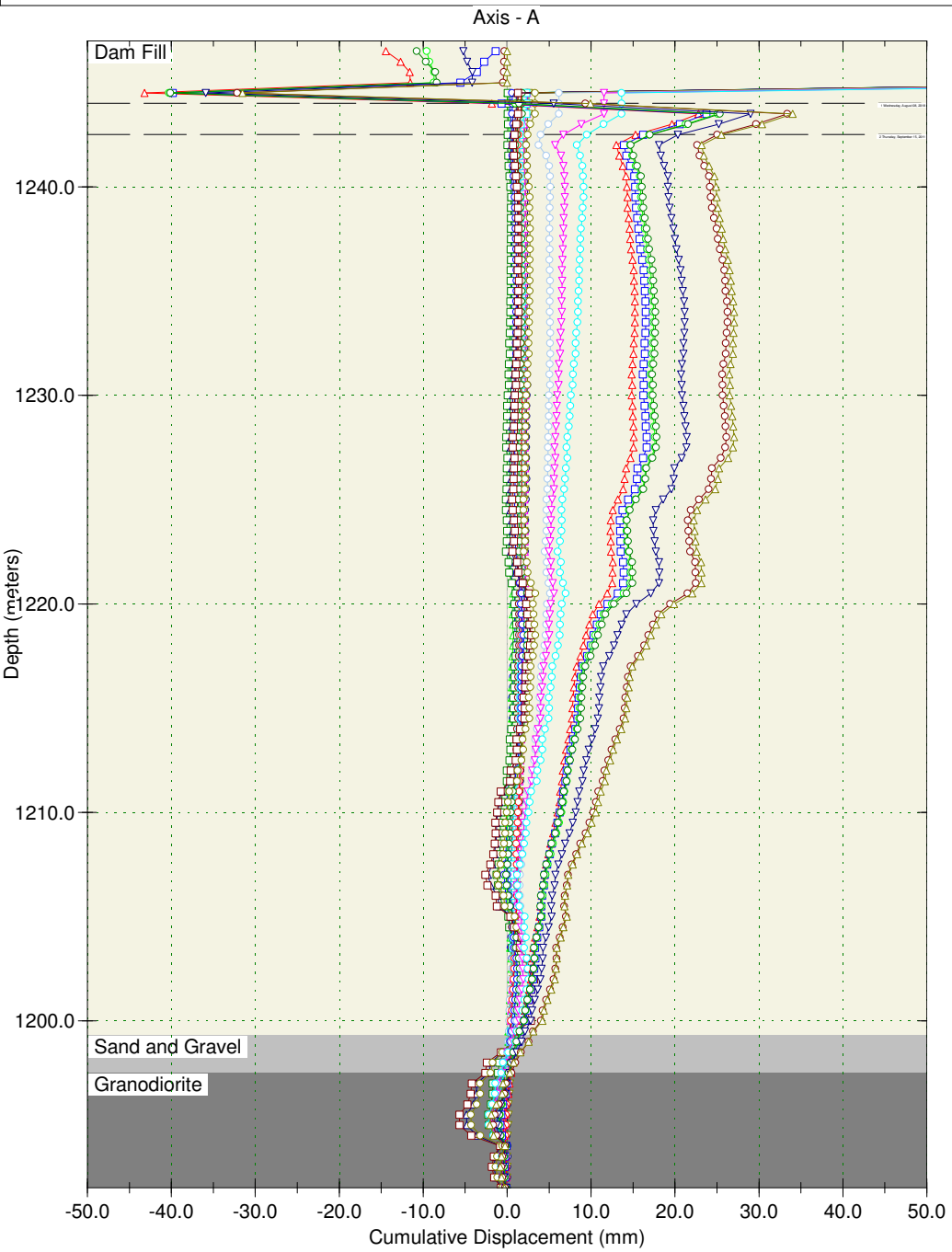
RST Instruments Ltd.

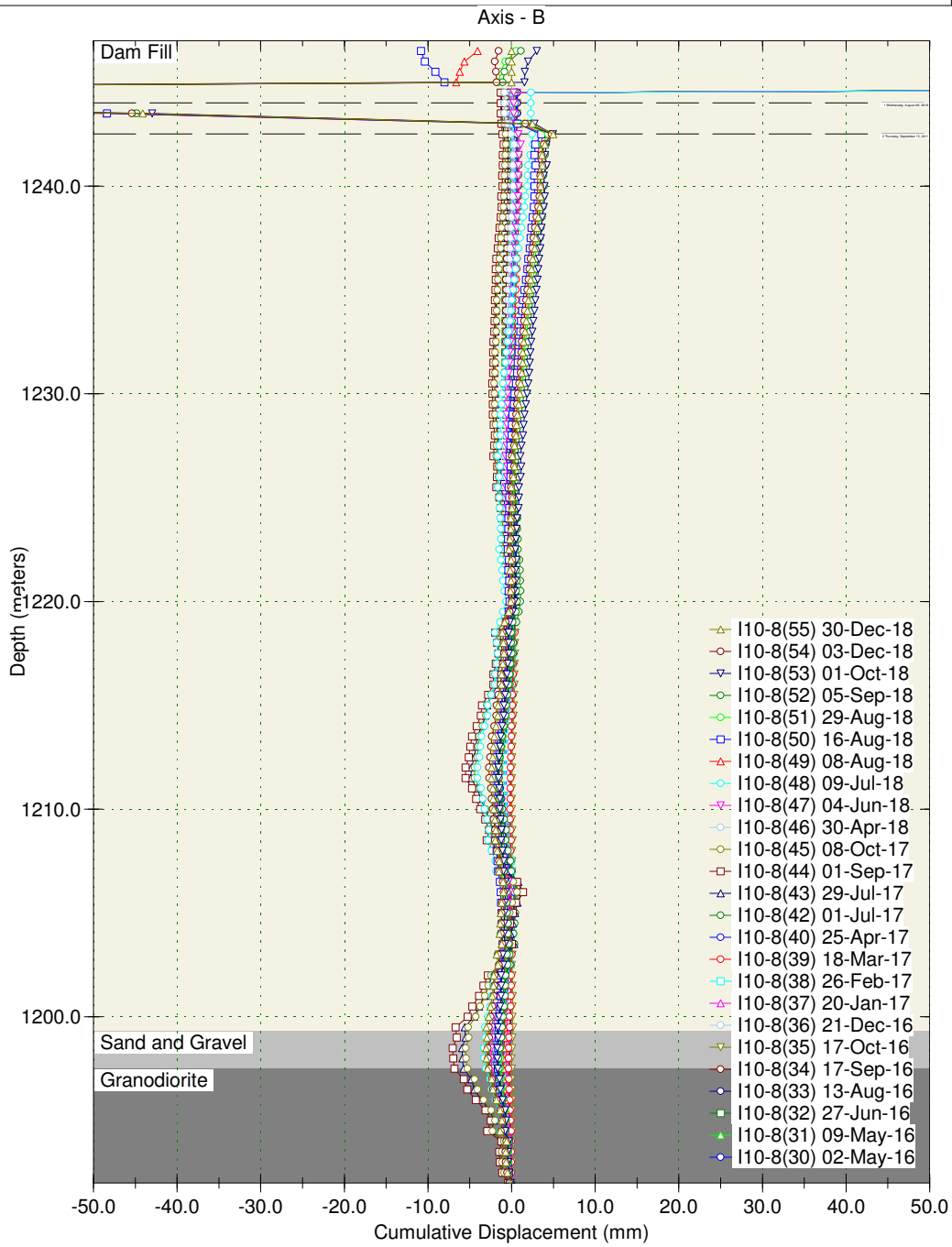
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I10-8
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1247.00 meters
Reading Depth : 55.0 meters
A+ Groove Azimuth :
Base Reading : 2016 Feb 17 13:27
Applied Azimuth : 0.0 degrees





RST Instruments Ltd.

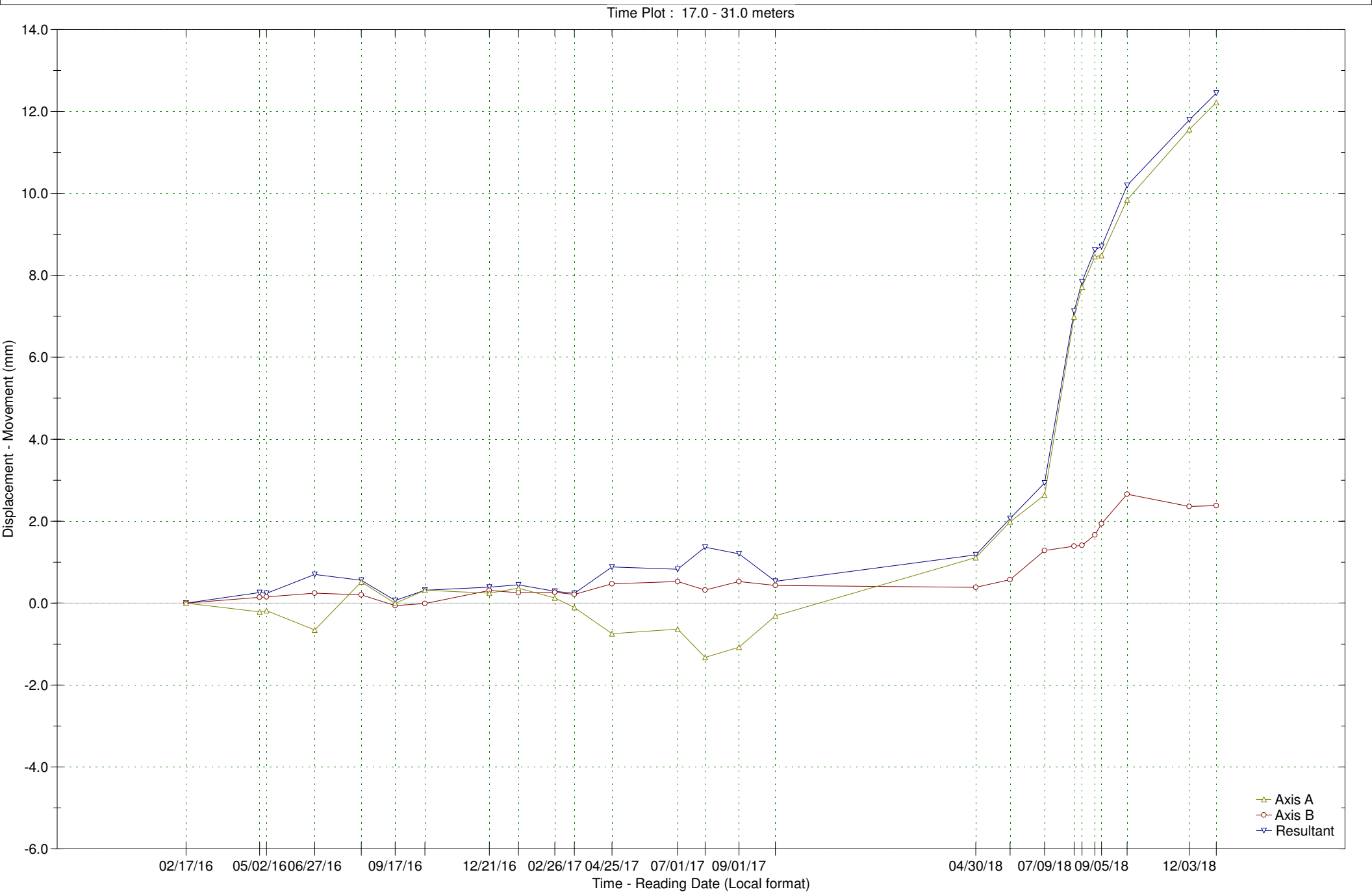
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I10-8
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1247.00 meters

Spiral Correction : N/A
Movement Depth : 17.0 - 31.0 meters
Reading Depth : 55.0 meters
A+ Groove Azimuth :
Latest Reading : 2018 Dec 30 20:55
Initial Reading : 2016 Feb 17 13:27
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

TIME PLOT

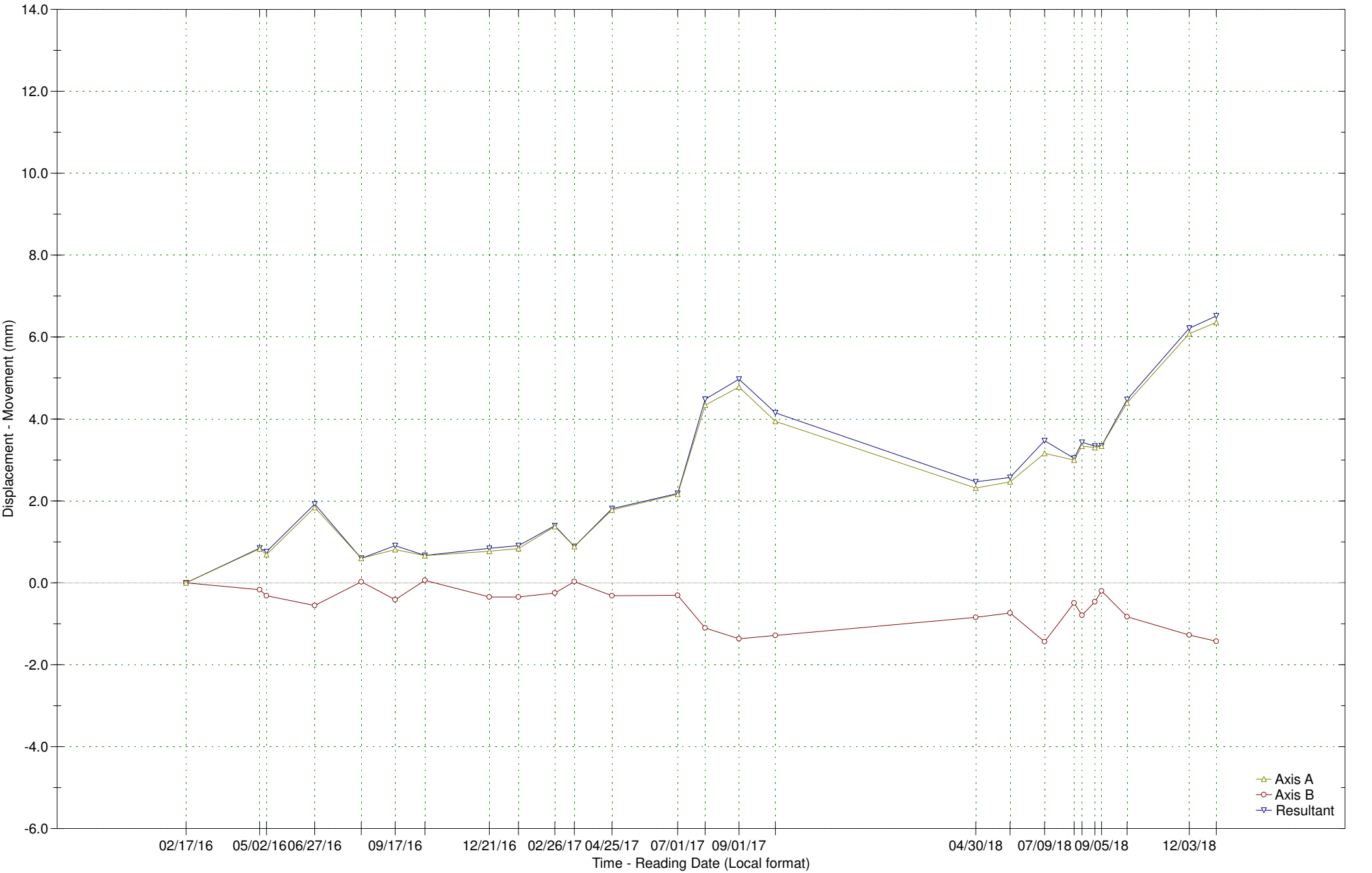
Displacement vs. Time

Inclinalysis v. 2.48.7

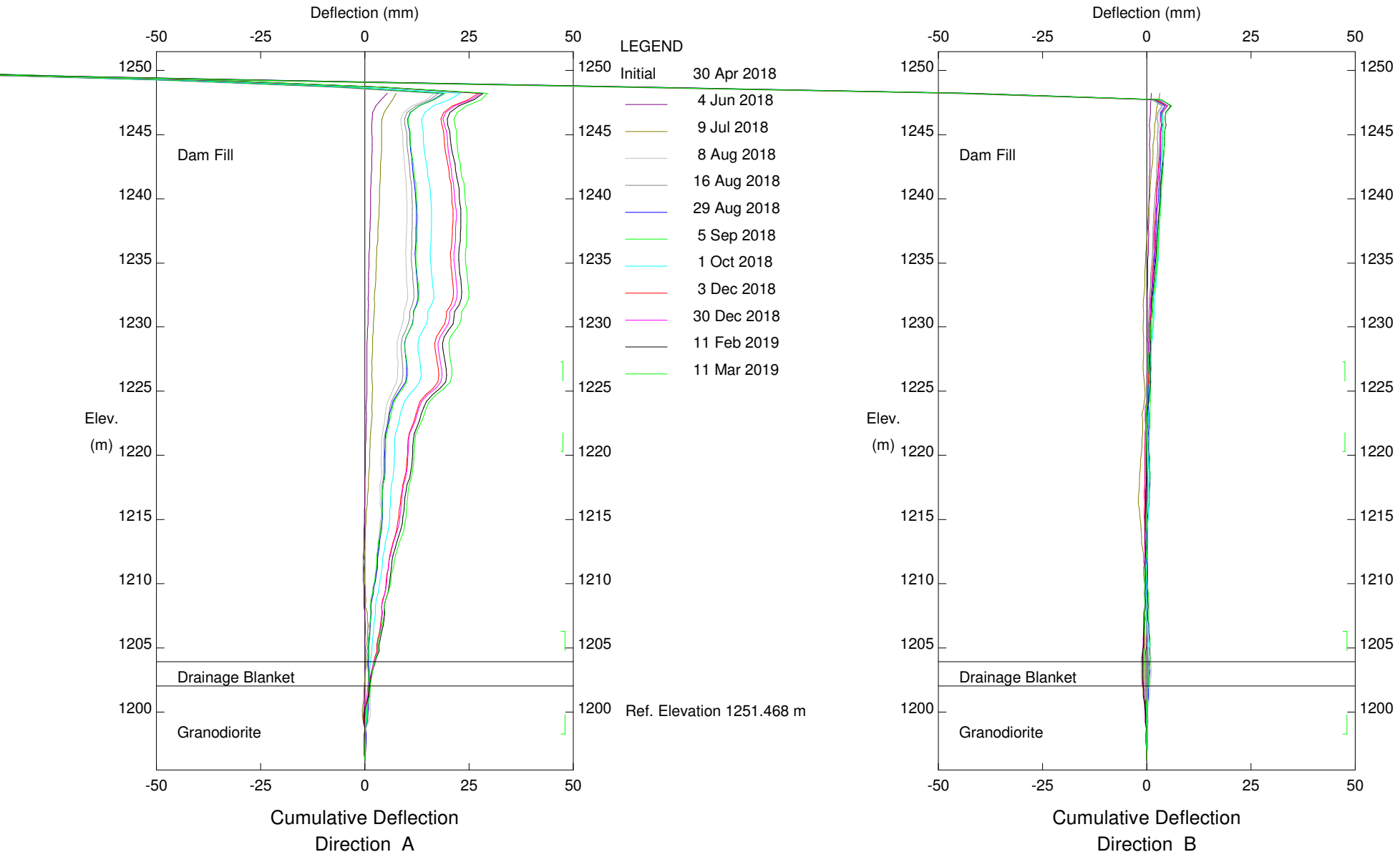
Borehole : I10-8
Project : 1----Including dam fill
Location :
Northing :
Easting :
Collar :
Collar Elev : 1247.00 meters

Spiral Correction : N/A
Movement Depth : 45.0 - 53.0 meters
Reading Depth : 55.0 meters
A+ Groove Azimuth :
Latest Reading : 2018 Dec 30 20:55
Initial Reading : 2016 Feb 17 13:27
Applied Azimuth : 0.0 degrees

Time Plot : 45.0 - 53.0 meters



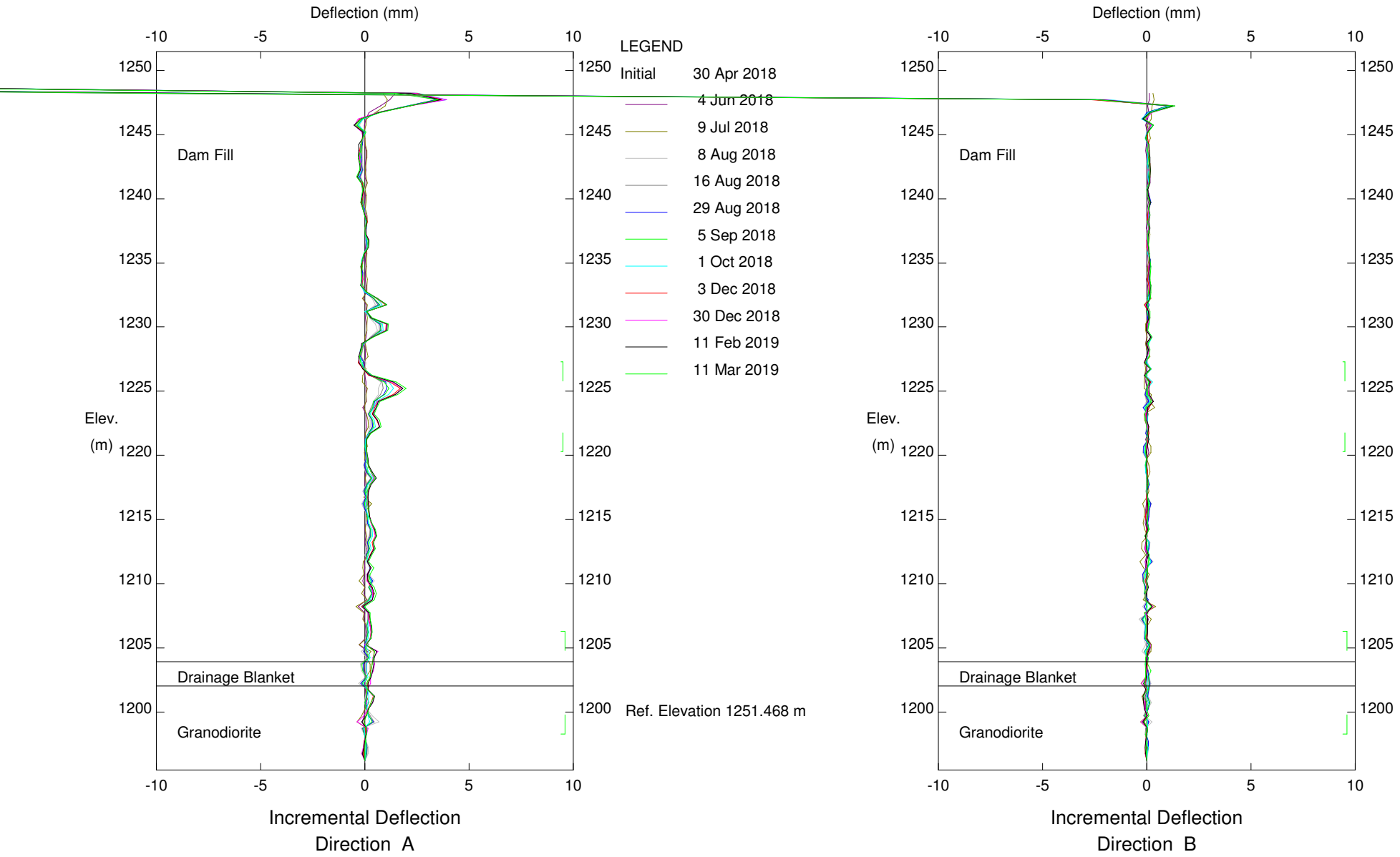
Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded, Inclinometer I10-8

V:\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\L-L Dam\SI Monitoring\Inclinalysis Files\1----Including dam fill\I10-8\GTILT\I10-8.gtl

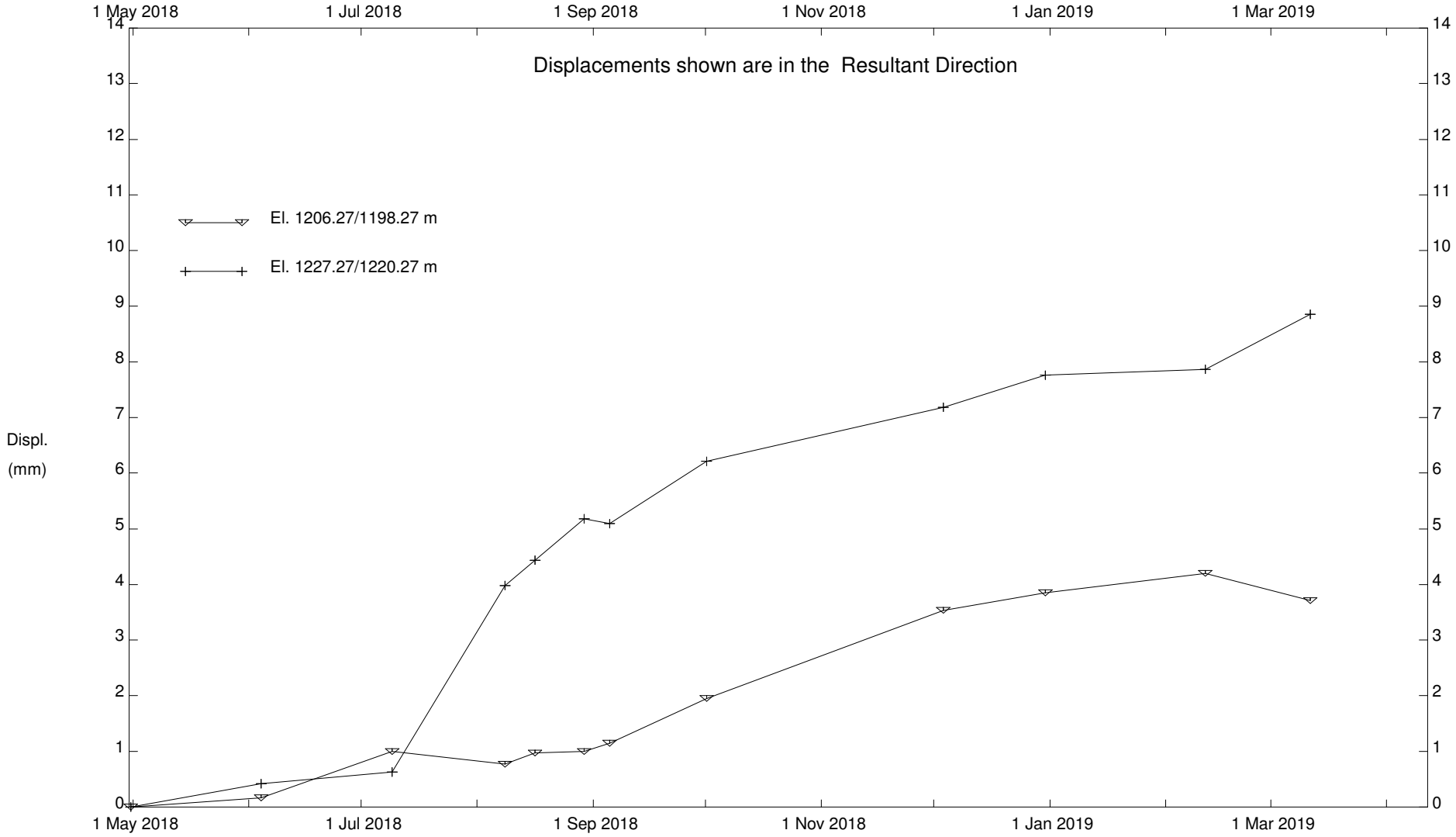
Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded, Inclinometer I10-8

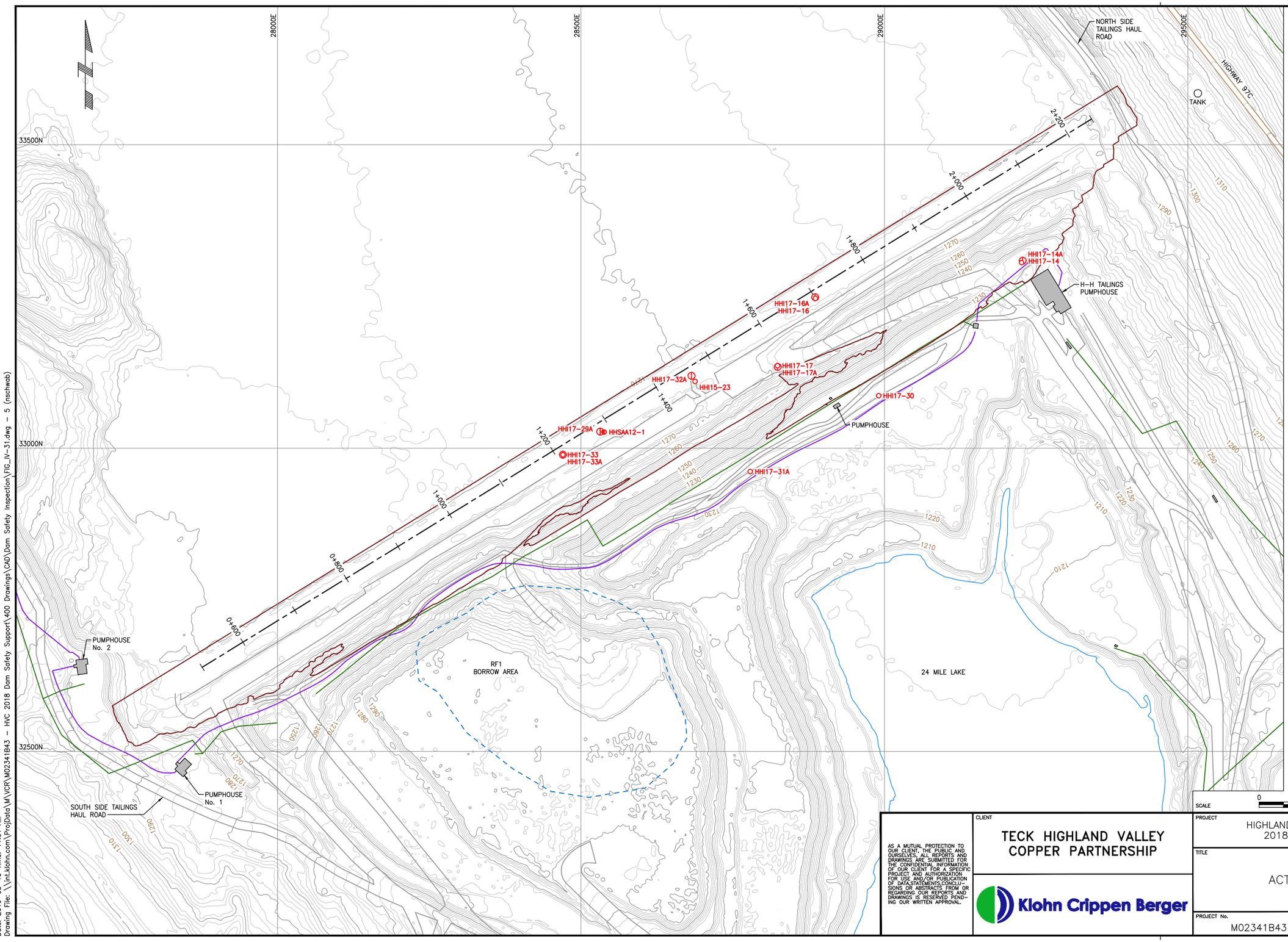
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Highland Valley Copper - Logan Lake, BC



Dam Fill Excluded, Inclinometer I10-8

H-H DAM INCLINOMETER LOCATION PLAN



LEGEND:

- BORROW AREA
- ULTIMATE DAM FOOTPRINT
- TAILINGS PIPELINE
- POWERLINE
- HAUL ROAD
- PUBLIC ROAD
- H-H DAM CENTERLINE (0+800)

ACTIVE INSTRUMENTS (SEE NOTE 2):

- STANDARD INCLINOMETER
- COMBINED STANDARD INCLINOMETER AND IN-PLACE SAA INCLINOMETER
- COMBINED STANDARD INCLINOMETER AND PAIRED SONDEX SETTLEMENT SYSTEM

NOTES:

1. TOPOGRAPHY PROVIDED BY TECK HIGHLAND VALLEY COPPER PARTNERSHIP AND WAS DERIVED FROM SATELLITE IMAGERY TAKEN ON 2018-10-06 AND 2016-09-25 & 28.
2. ACTIVE INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: CURRENTLY READING AN ACTIVE WATER LEVEL, DRY OR PLUGGED <20 m ABOVE TIP ELEVATION AS THIS COULD SHOW A RESPONSE IN THE FUTURE.
3. ASTERISK (*) DENOTES PROPOSED INSTRUMENT LOCATION TO BE UPDATED WITH AS-CONSTRUCTED LOCATION WHEN SURVEY IS COMPLETED.

SCALE 0 200 m

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

TITLE
H-H DAM
ACTIVE INCLINOMETERS
LOCATION PLAN

PROJECT No. M02341B43

FIG. No. IV-31

KCB-R-MLD

Date: 2019-03-15 Time: 11:01 AM
Drawing File: \\int.klohn.com\ProjData\M\VCR\M02341B43 - HVC 2018 Dam Safety Support\400 Drawings\CAD\Dam Safety Inspection\FIG_IV-31.dwg - 5 (nschwab)

H-H DAM

HH I15-23

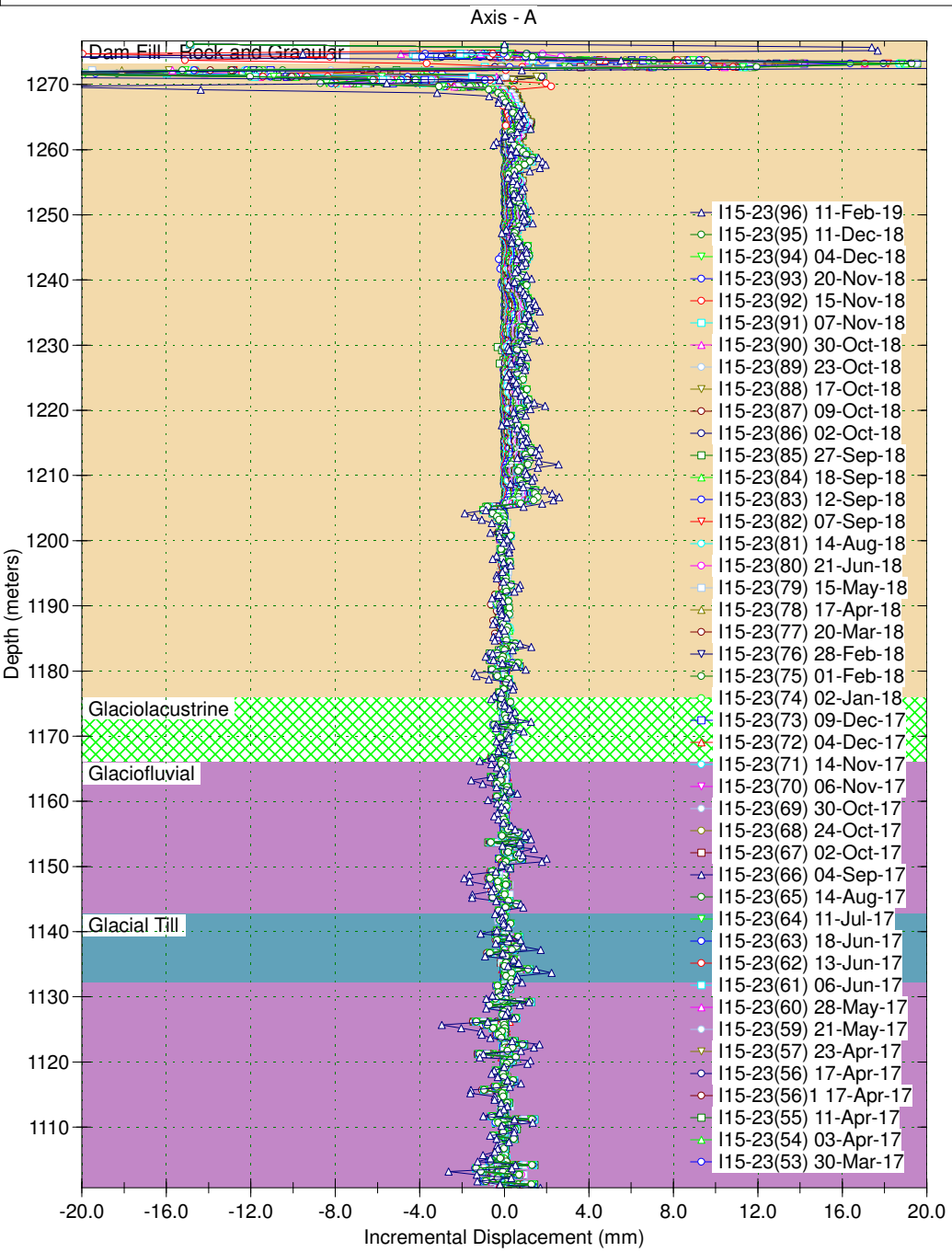
RST Instruments Ltd.

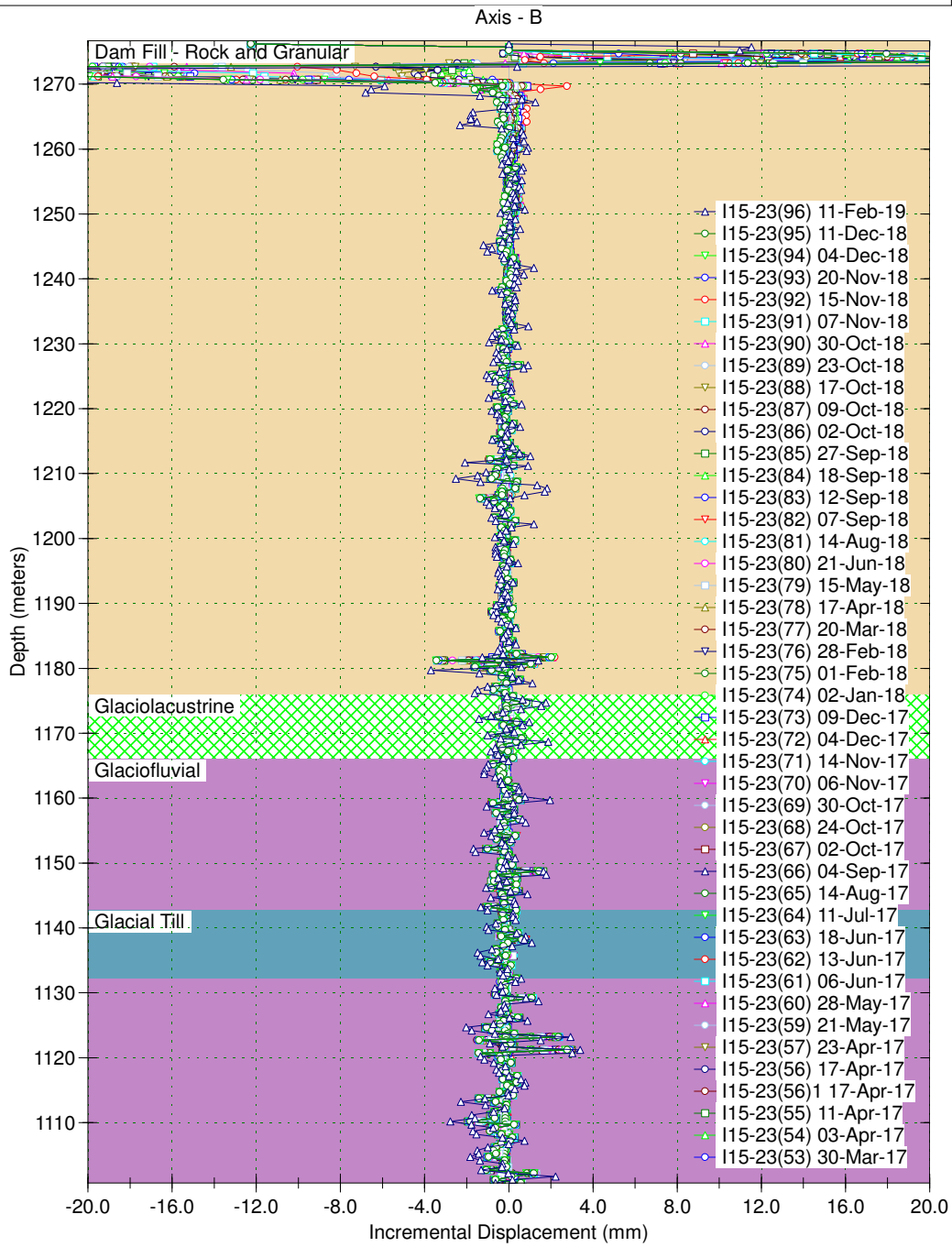
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : Reel 1
Project : RMR Historical
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1276.70 meters
Reading Depth : 176.0 meters
A+ Groove Azimuth :
Base Reading : 2017 Mar 28 12:36
Applied Azimuth : 0.0 degrees





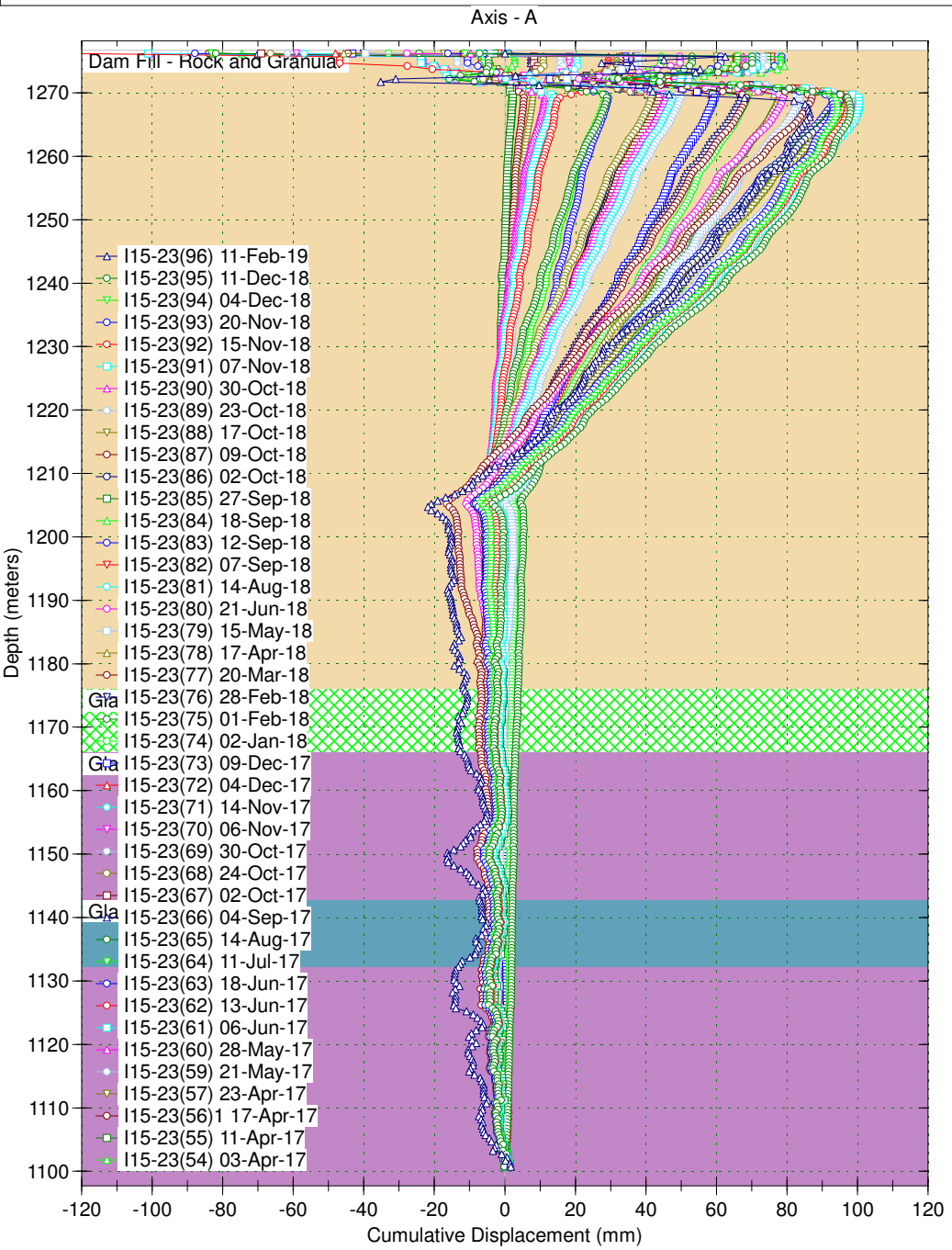
RST Instruments Ltd.

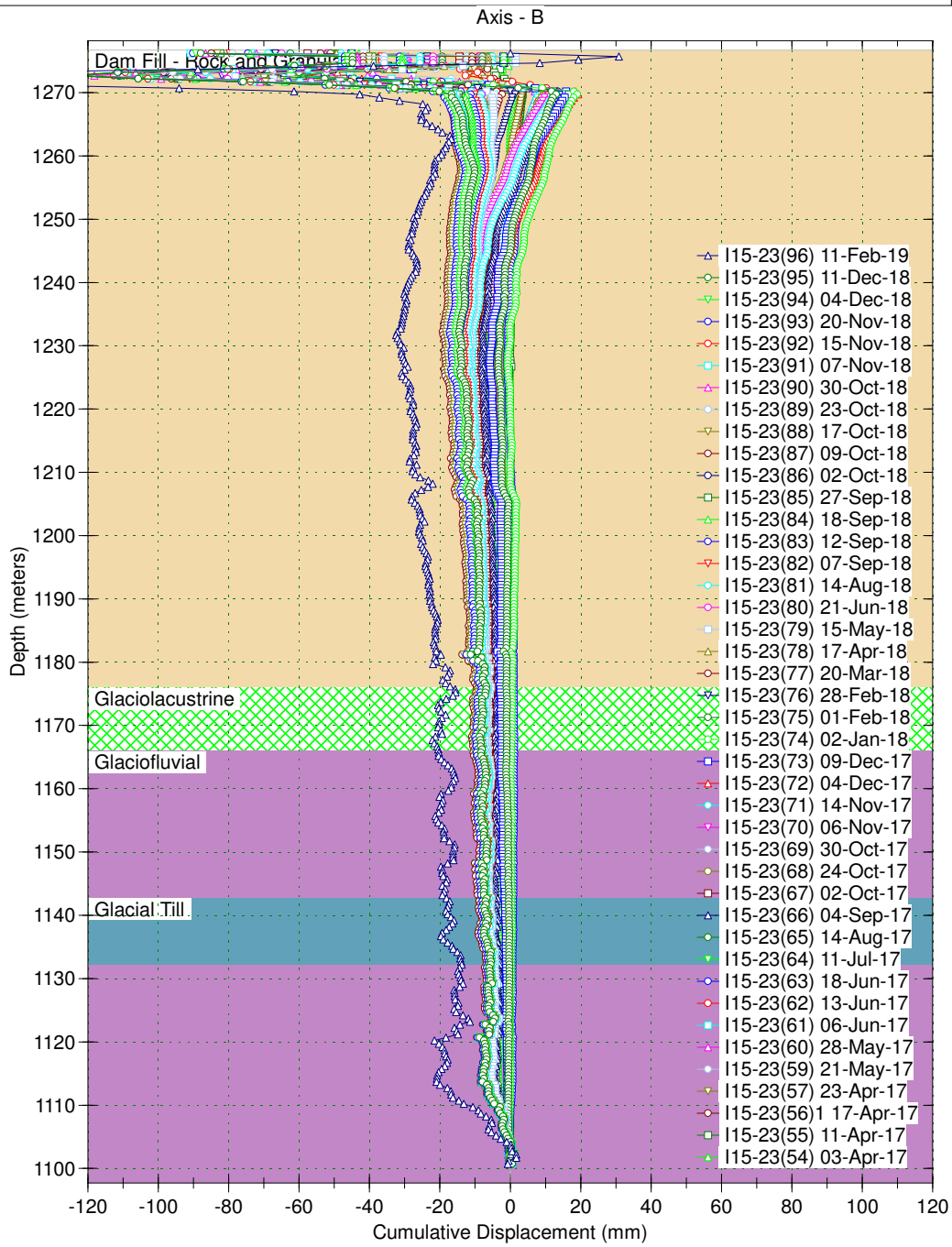
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : Reel 1
Project : RMR Historical
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1276.70 meters
Reading Depth : 176.0 meters
A+ Groove Azimuth :
Base Reading : 2017 Mar 30 15:17
Applied Azimuth : 0.0 degrees





RST Instruments Ltd.

TIME PLOT

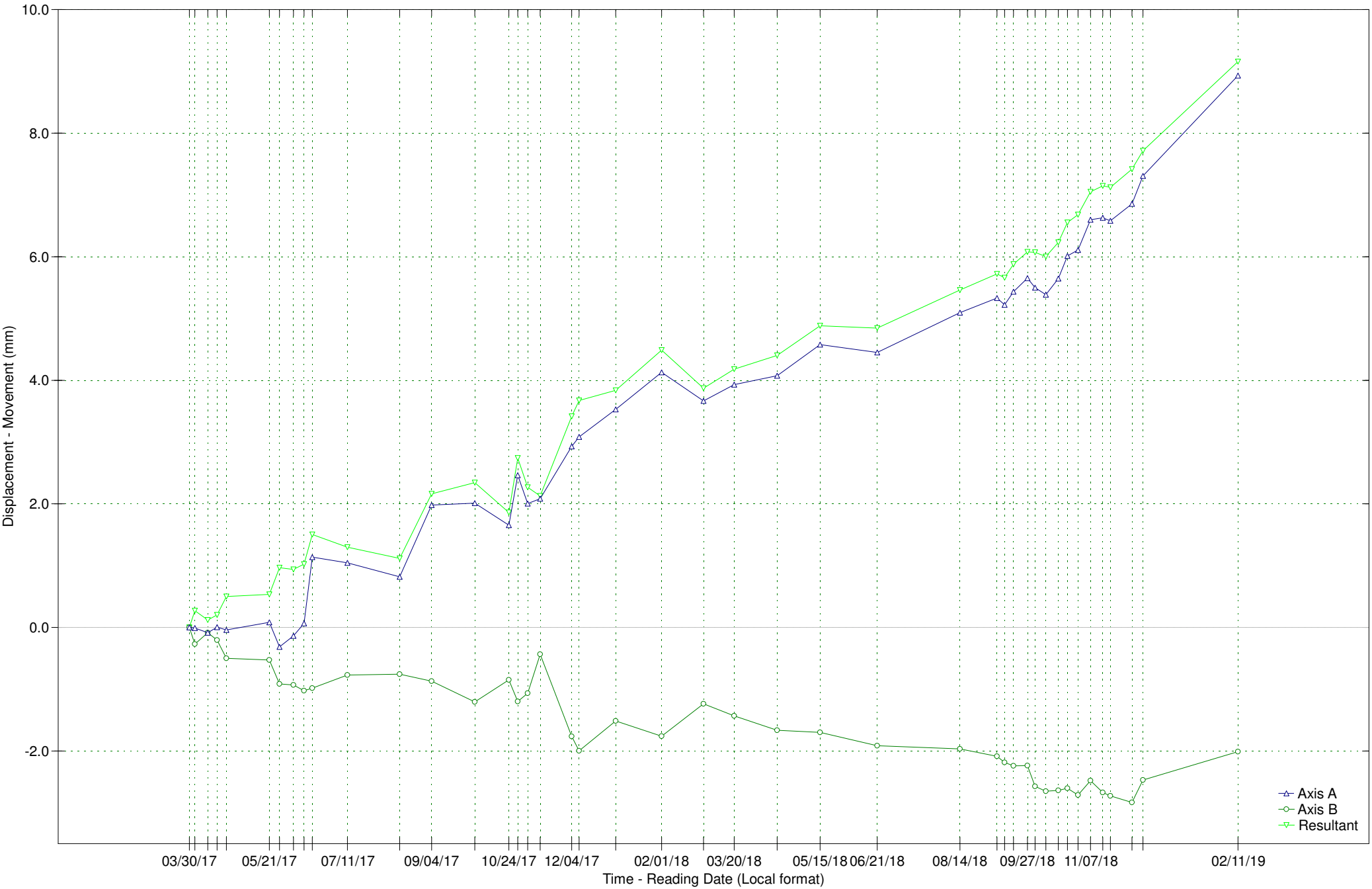
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : Reel 1
Project : RMR Historical
Location :
Northing :
Easting :
Collar :
Collar Elev : 1276.70 meters

Spiral Correction : N/A
Movement Depth : 67.0 - 77.0 meters
Reading Depth : 176.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 11 10:19
Initial Reading : 2017 Mar 30 15:17
Applied Azimuth : 0.0 degrees

Time Plot : 67.0 - 77.0 meters



RST Instruments Ltd.

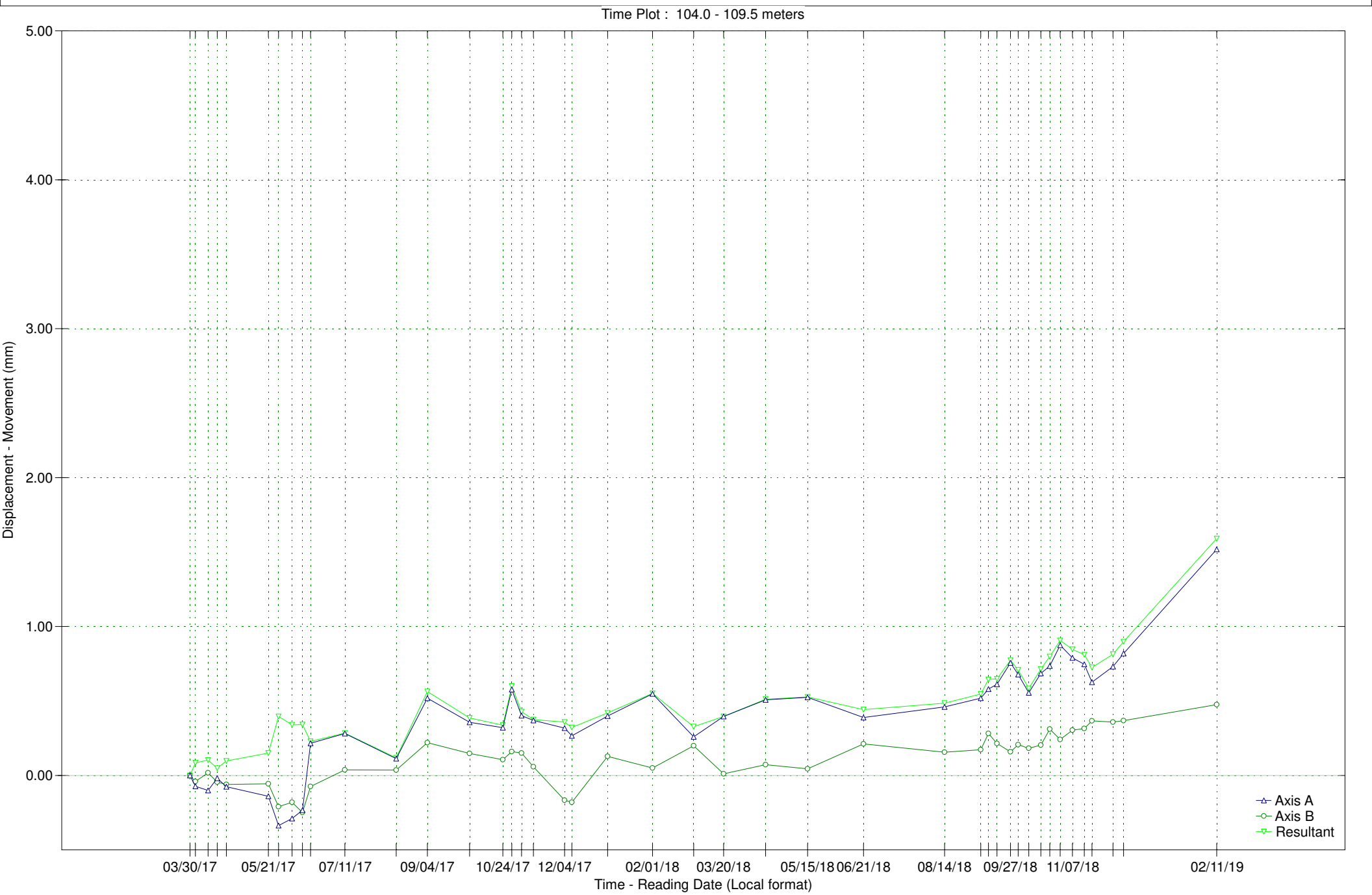
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : Reel 1
Project : RMR Historical
Location :
Northing :
Easting :
Collar :
Collar Elev : 1276.70 meters

Spiral Correction : N/A
Movement Depth : 104.0 - 109.5 meters
Reading Depth : 176.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 11 10:19
Initial Reading : 2017 Mar 30 15:17
Applied Azimuth : 0.0 degrees



H-H DAM

HH I17-14

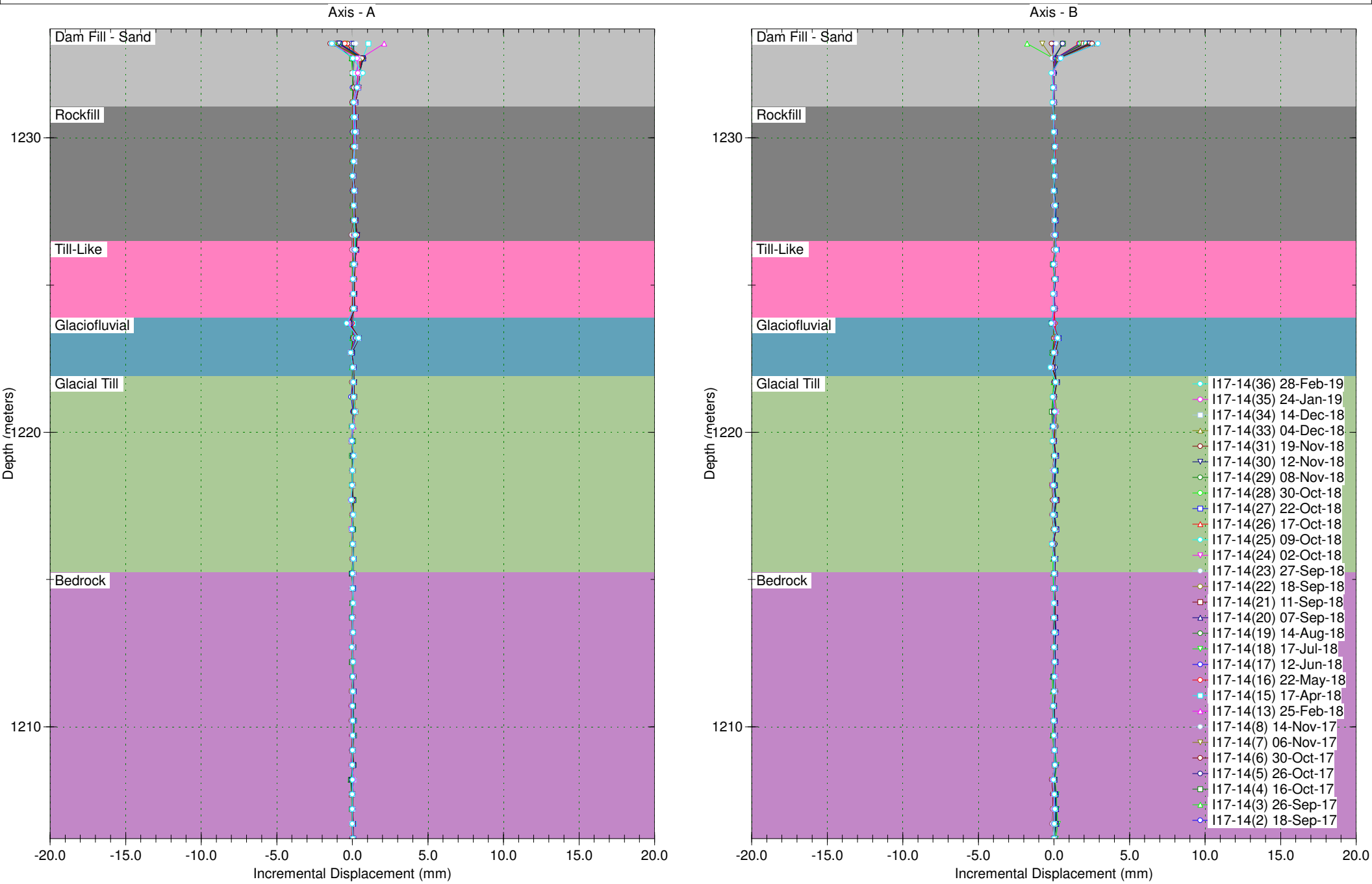
RST Instruments Ltd.

INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-14
Location :
Northing :
Easting :
Collar :

Spiral Correction : Enabled
Collar Elevation : :1233.70 meters
Reading Depth : 27.5 meters
A+ Groove Azimuth :
Base Reading : 2017 Sep 18 14:02
Applied Azimuth : 0.0 degrees



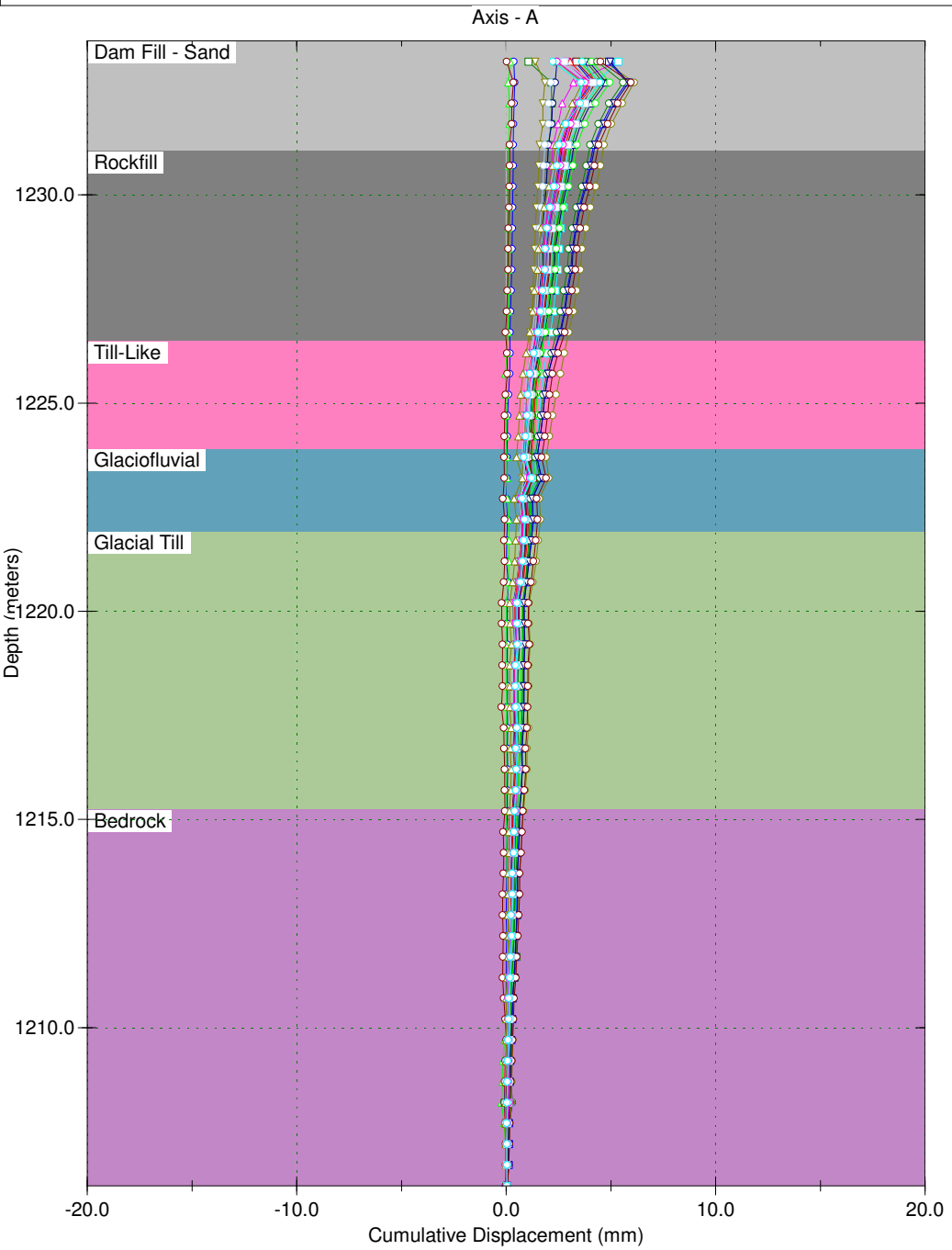
RST Instruments Ltd.

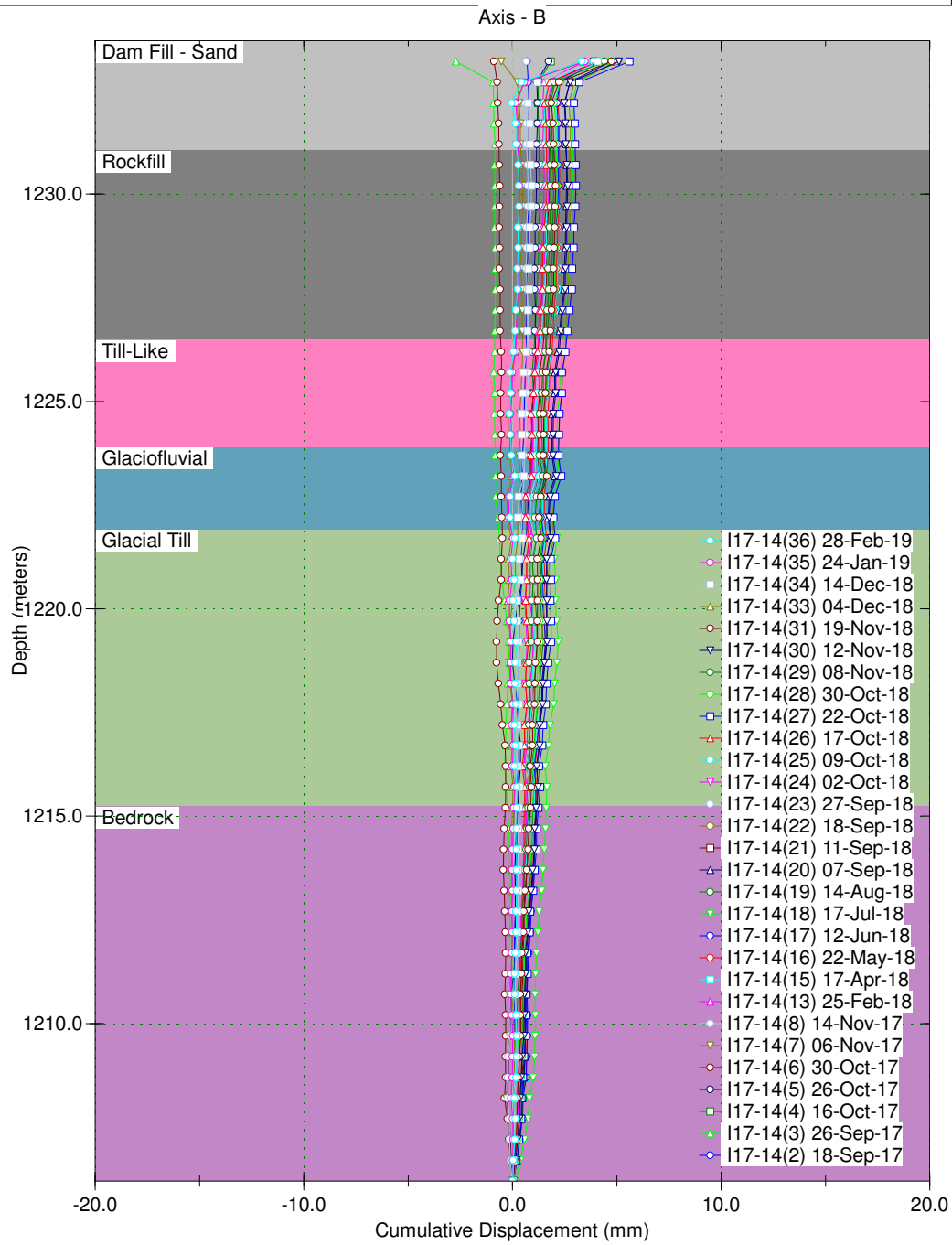
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-14
Location :
Northing :
Easting :
Collar :

Spiral Correction : Enabled
Collar Elevation : :1233.70 meters
Reading Depth : 27.5 meters
A+ Groove Azimuth :
Base Reading : 2017 Sep 18 14:02
Applied Azimuth : 0.0 degrees





RST Instruments Ltd.

TIME PLOT

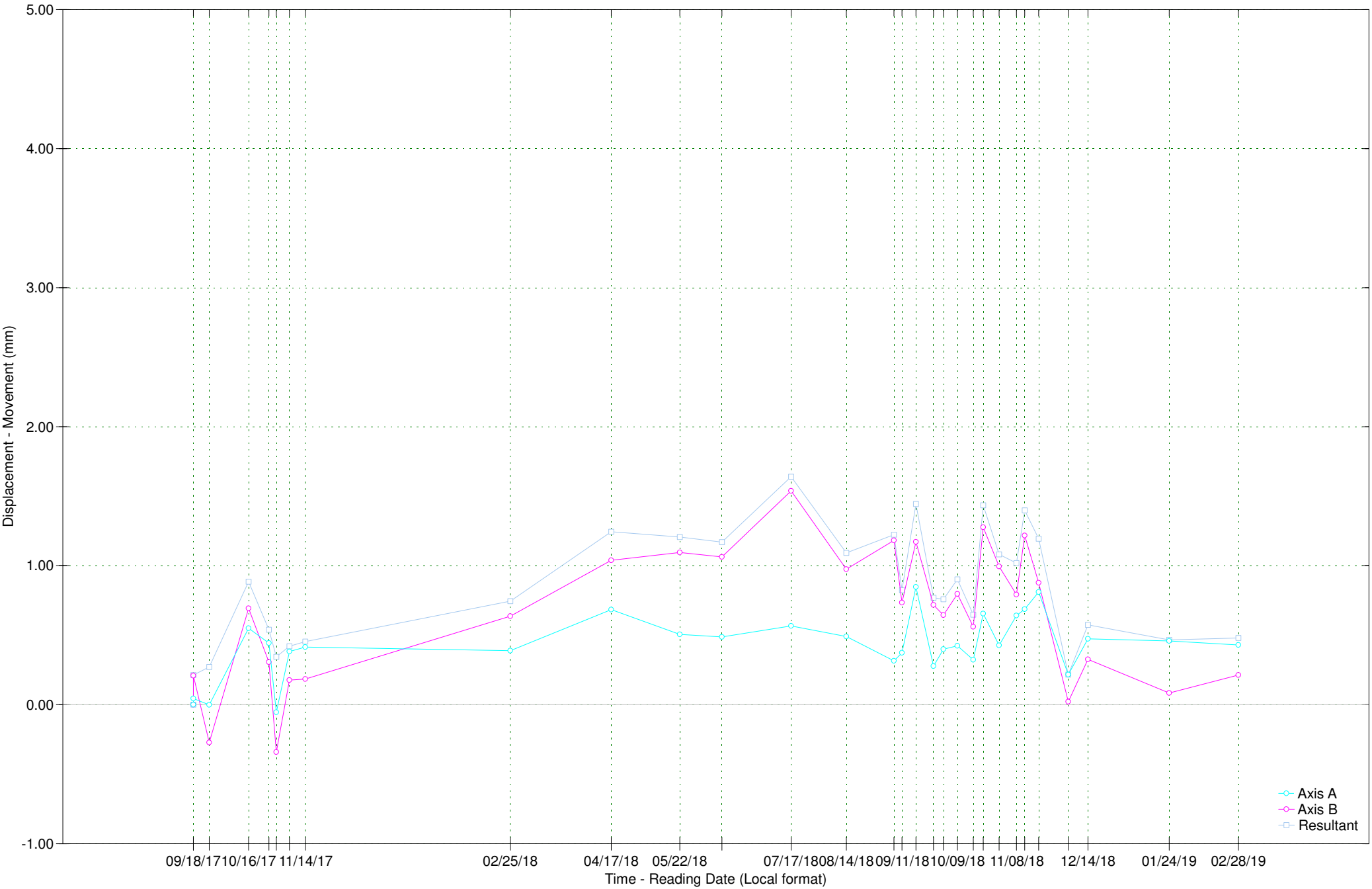
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-14
Location :
Northing :
Easting :
Collar :
Collar Elev : 1233.70 meters

Spiral Correction : Enabled
Movement Depth : 18.0 - 27.0 meters
Reading Depth : 27.5 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 28 11:53
Initial Reading : 2017 Sep 18 14:02
Applied Azimuth : 0.0 degrees

Time Plot : 18.0 - 27.0 meters



RST Instruments Ltd.

TIME PLOT

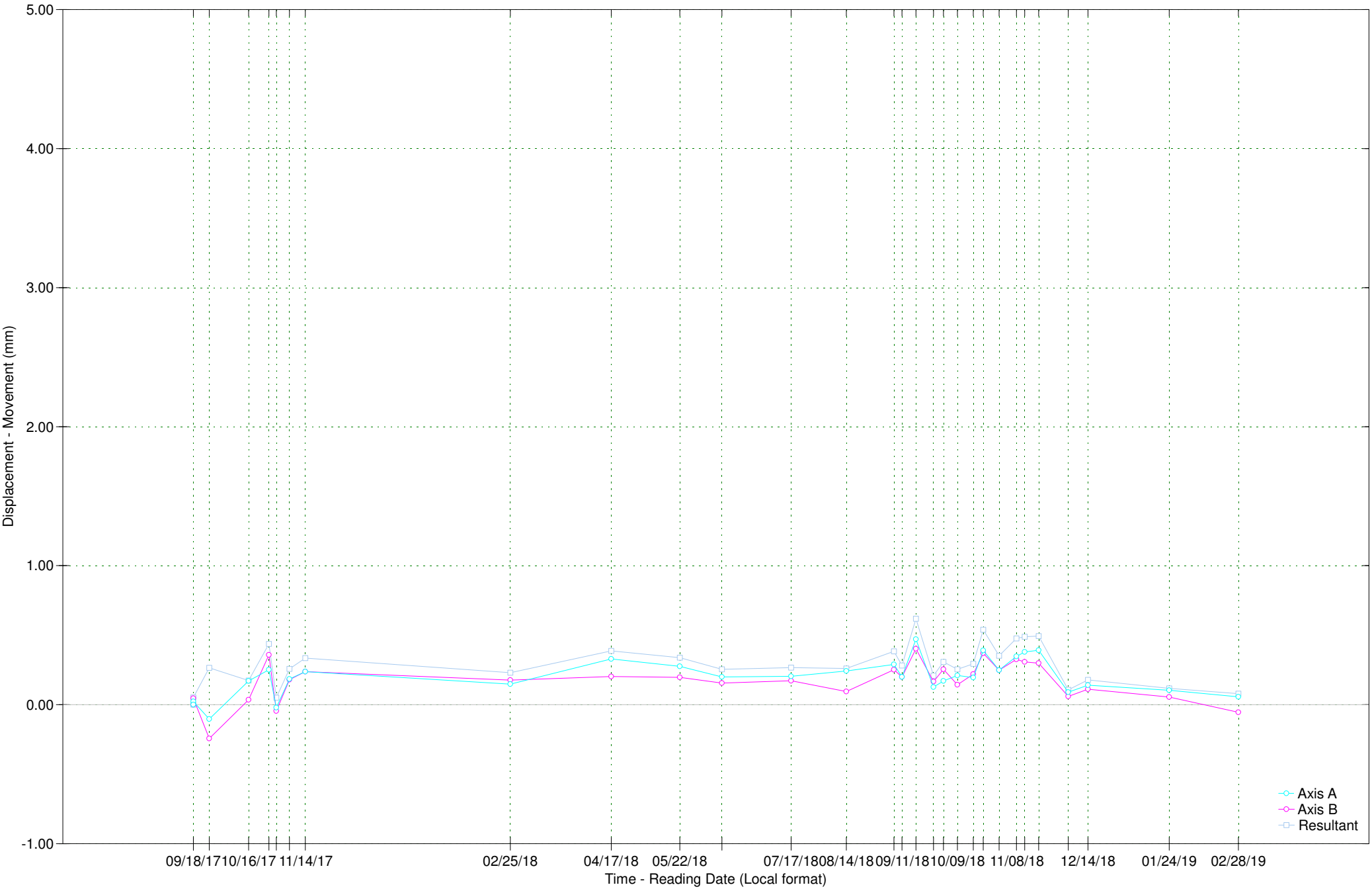
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-14
Location :
Northing :
Easting :
Collar :
Collar Elev : 1233.70 meters

Spiral Correction : Enabled
Movement Depth : 10.0 - 12.0 meters
Reading Depth : 27.5 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 28 11:53
Initial Reading : 2017 Sep 18 14:02
Applied Azimuth : 0.0 degrees

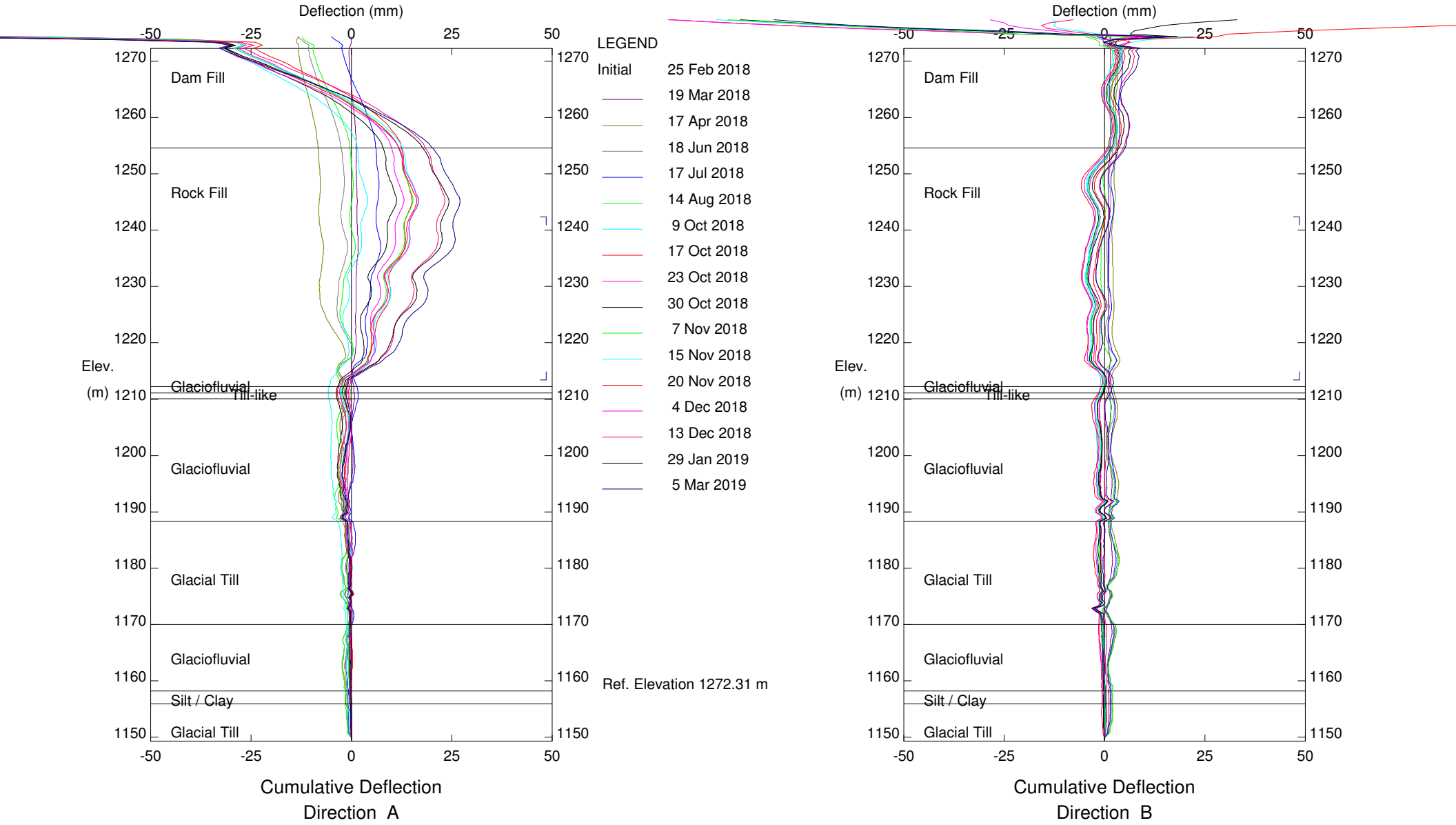
Time Plot : 10.0 - 12.0 meters



H-H DAM

HH I17-16

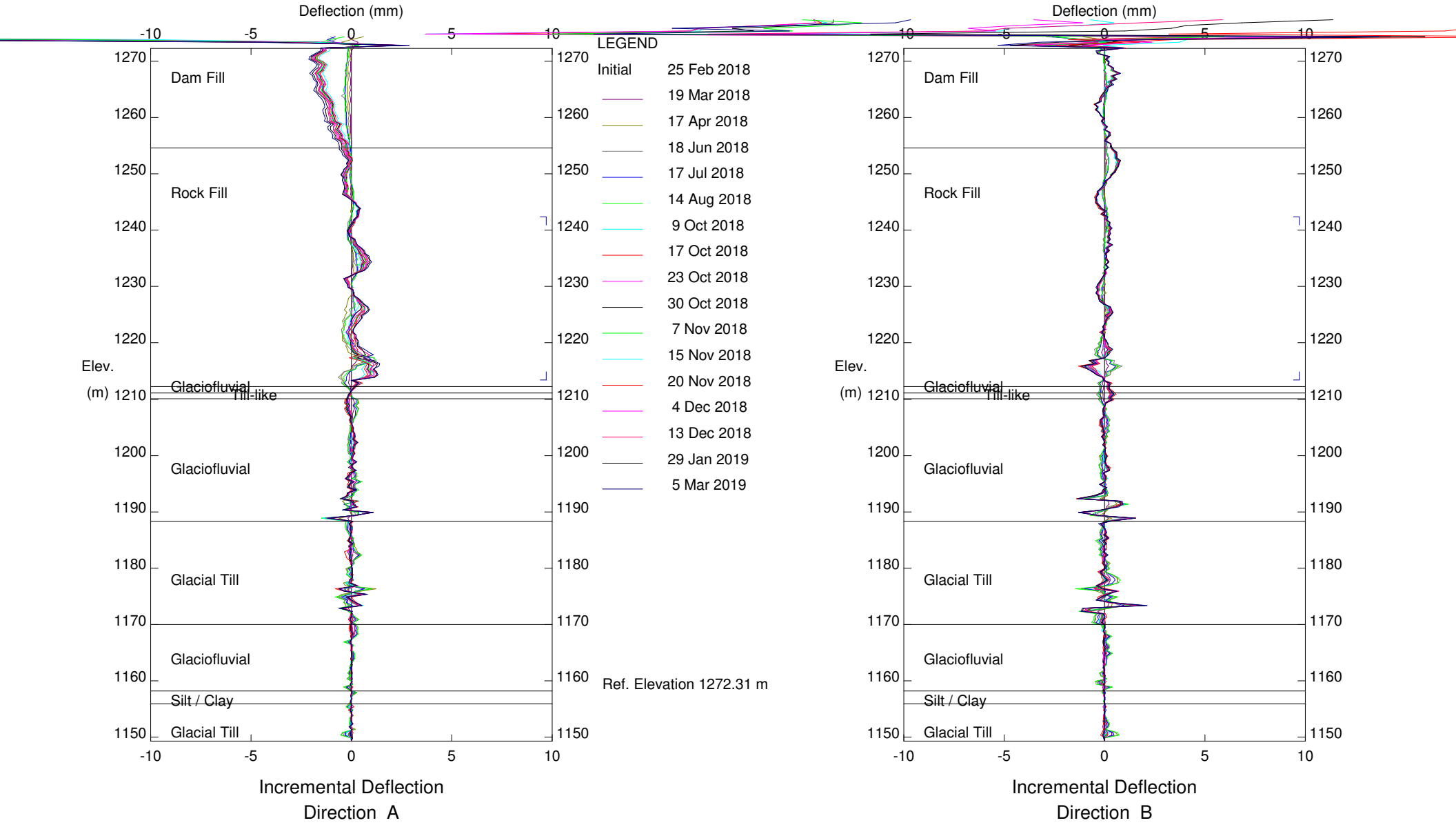
Highland Valley Copper - Logan Lake, BC



H-H Dam, Inclinometer I17-16

V:\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\H-H Dam\SI Monitoring\HH Dam\I17-16\GTILT\I17-16.gtl

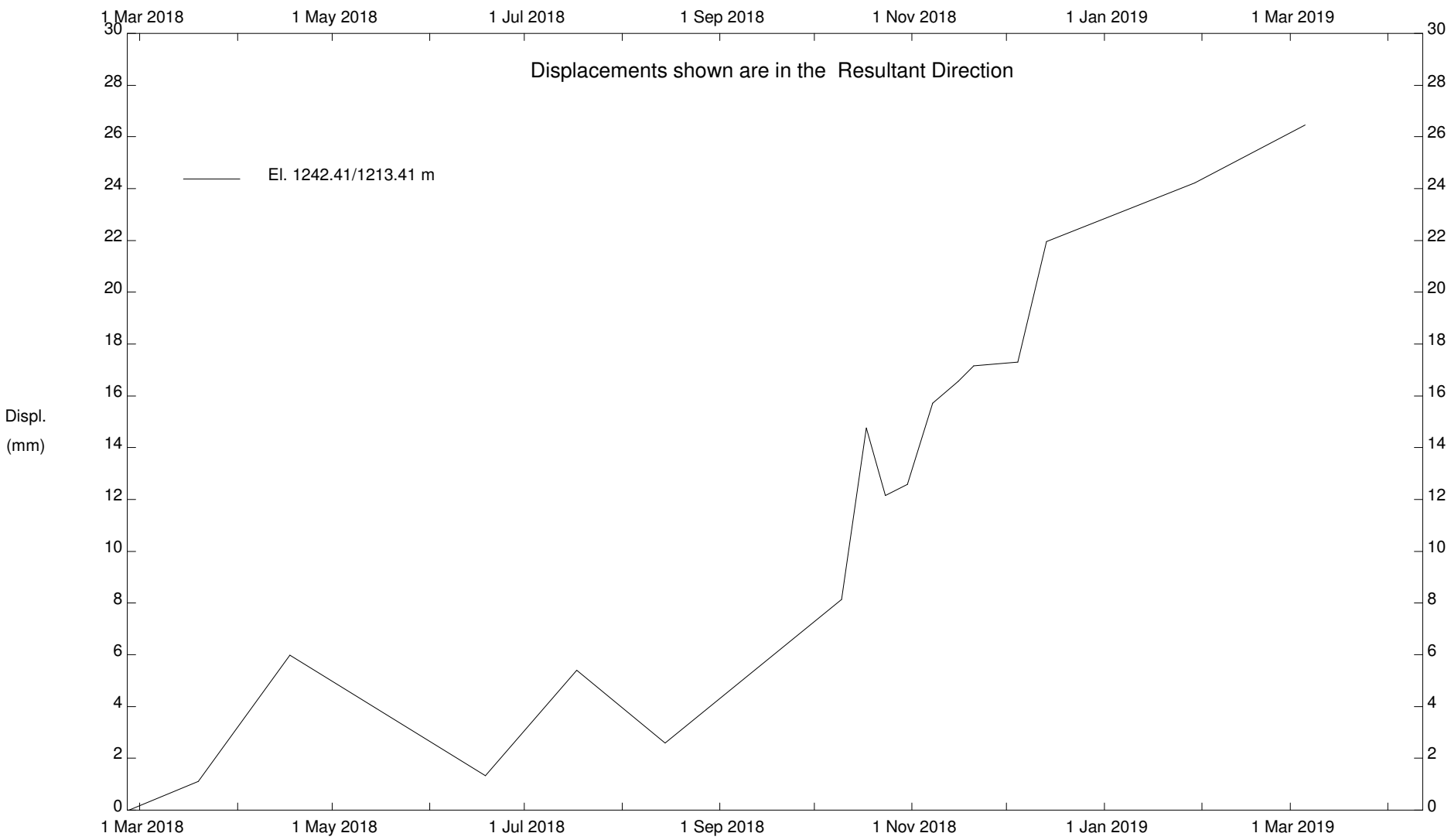
Highland Valley Copper - Logan Lake, BC



H-H Dam, Inclinometer I17-16

V:\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\H-H Dam\SI Monitoring\HH Dam\I17-16\GTILT\I17-16.gtl

Highland Valley Copper - Logan Lake, BC



H-H Dam, Inclinometer I17-16

H-H DAM

HH I17-17

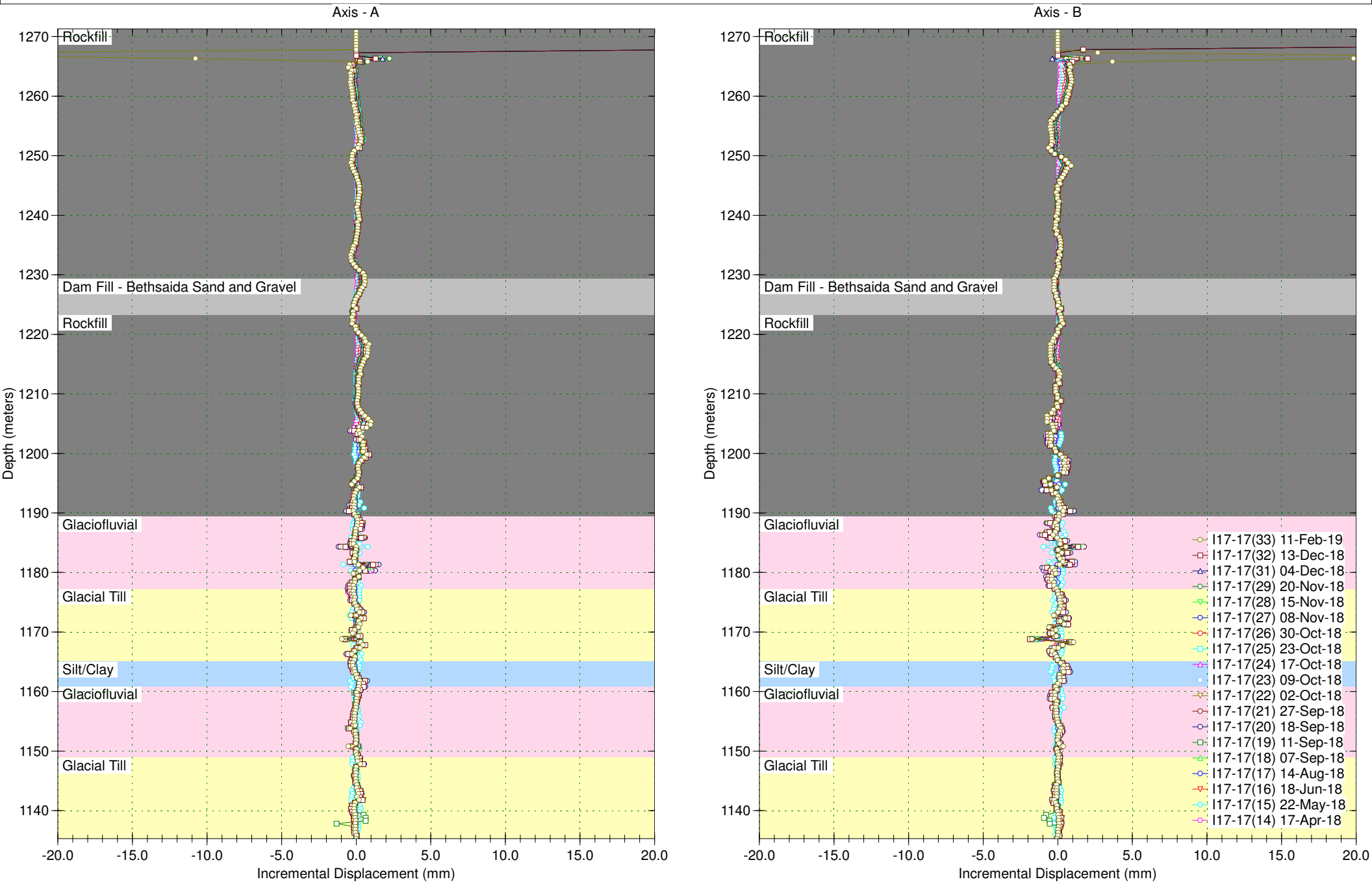
RST Instruments Ltd.

INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I17-17 Reel 2
Project : RMR Historical
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1271.30 meters
Reading Depth : 136.0 meters
A+ Groove Azimuth :
Base Reading : 2018 Mar 20 09:44
Applied Azimuth : 0.0 degrees



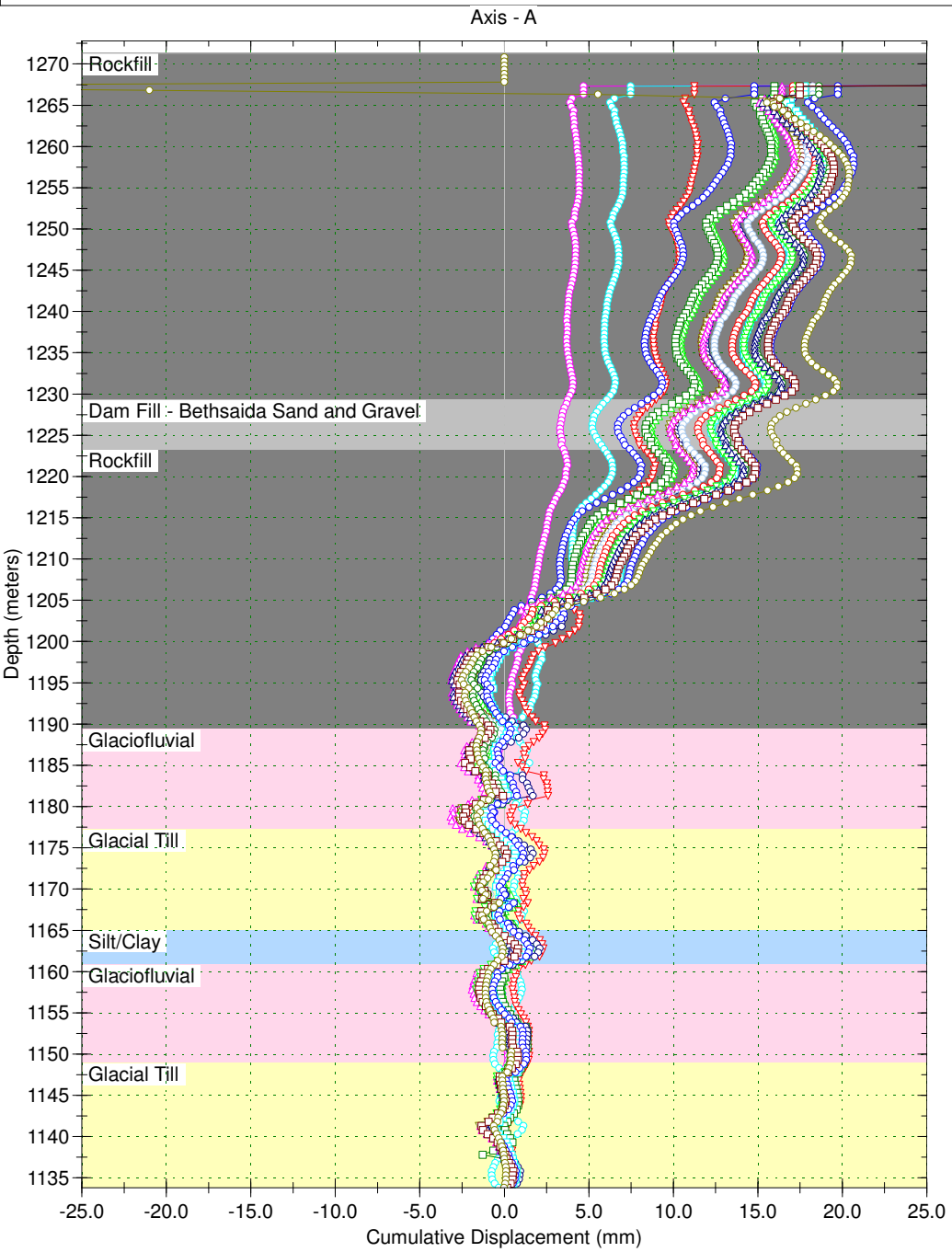
RST Instruments Ltd.

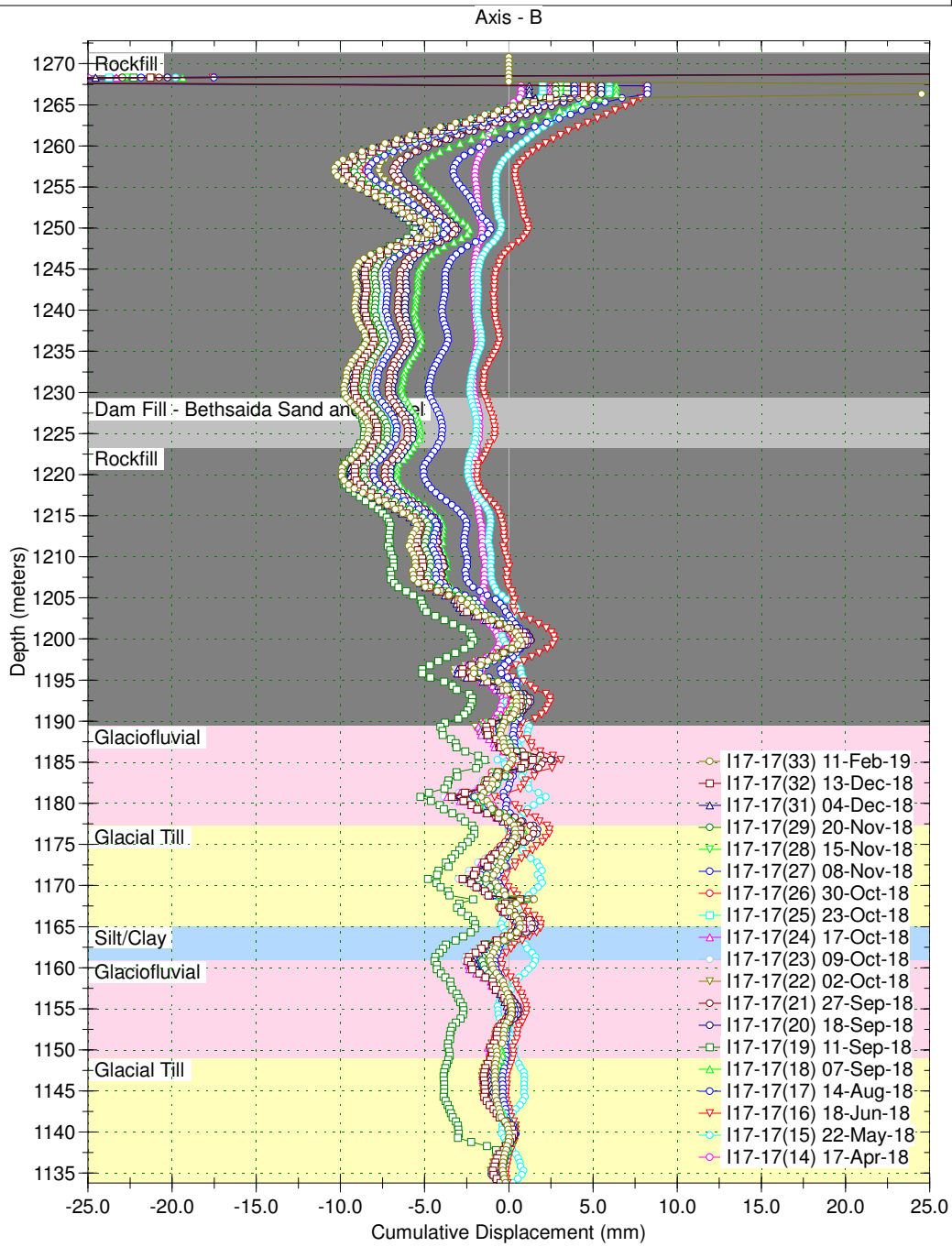
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : I17-17 Reel 2
Project : RMR Historical
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1271.30 meters
Reading Depth : 136.0 meters
A+ Groove Azimuth :
Base Reading : 2018 Mar 20 09:44
Applied Azimuth : 0.0 degrees





RST Instruments Ltd.

TIME PLOT

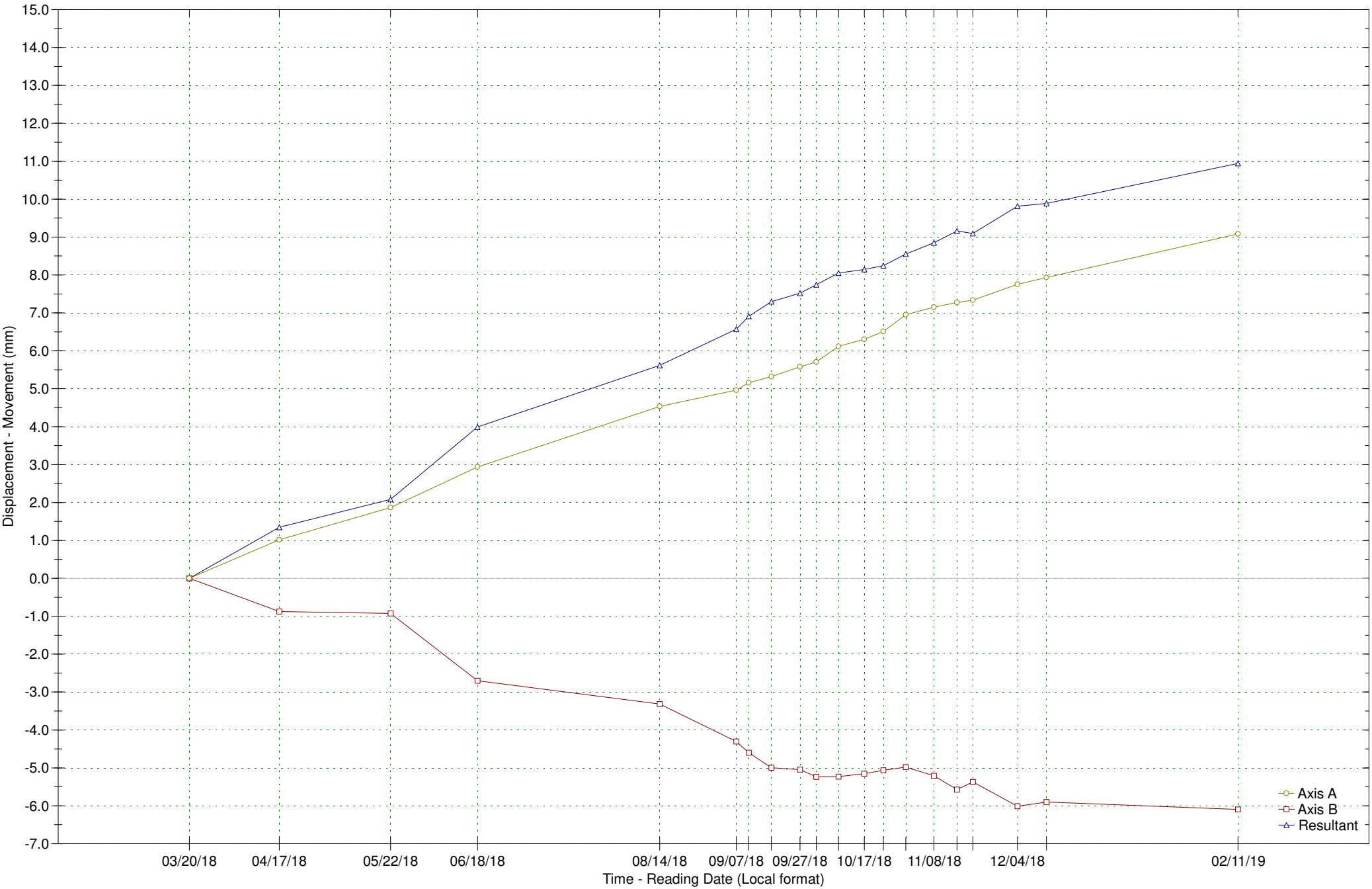
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I17-17 Reel 2
Project : RMR Historical
Location :
Northing :
Easting :
Collar :
Collar Elev : 1271.30 meters

Spiral Correction : N/A
Movement Depth : 61.5 - 71.5 meters
Reading Depth : 140.5 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 11 12:12
Initial Reading : 2018 Mar 20 09:44
Applied Azimuth : 0.0 degrees

Time Plot : 61.5 - 71.5 meters



RST Instruments Ltd.

TIME PLOT

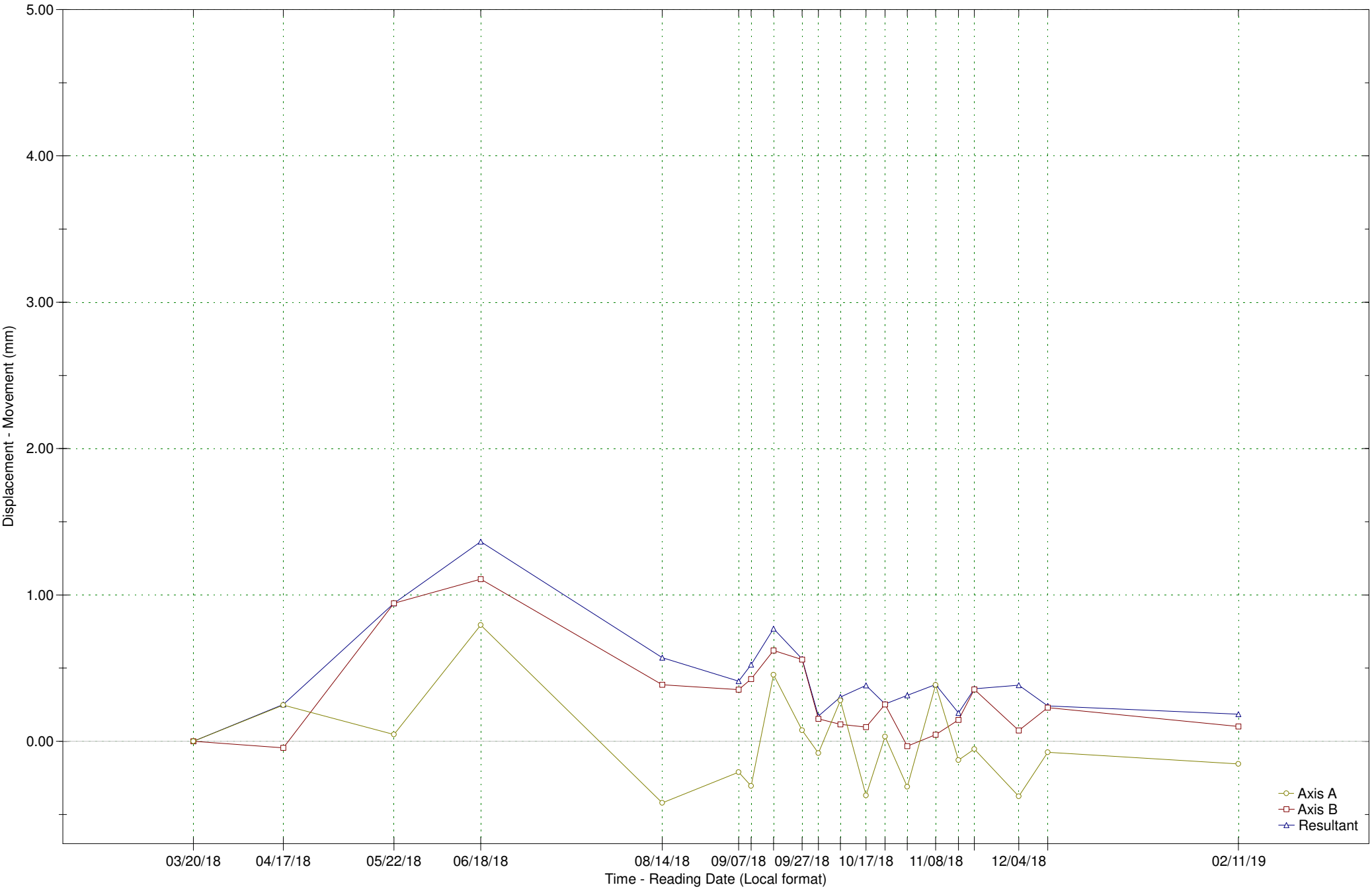
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I17-17 Reel 2
Project : RMR Historical
Location :
Northing :
Easting :
Collar :
Collar Elev : 1271.30 meters

Spiral Correction : N/A
Movement Depth : 96.0 - 117.0 meters
Reading Depth : 140.5 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 11 12:12
Initial Reading : 2018 Mar 20 09:44
Applied Azimuth : 0.0 degrees

Time Plot : 96.0 - 117.0 meters



H-H DAM

HH I17-30

RST Instruments Ltd.

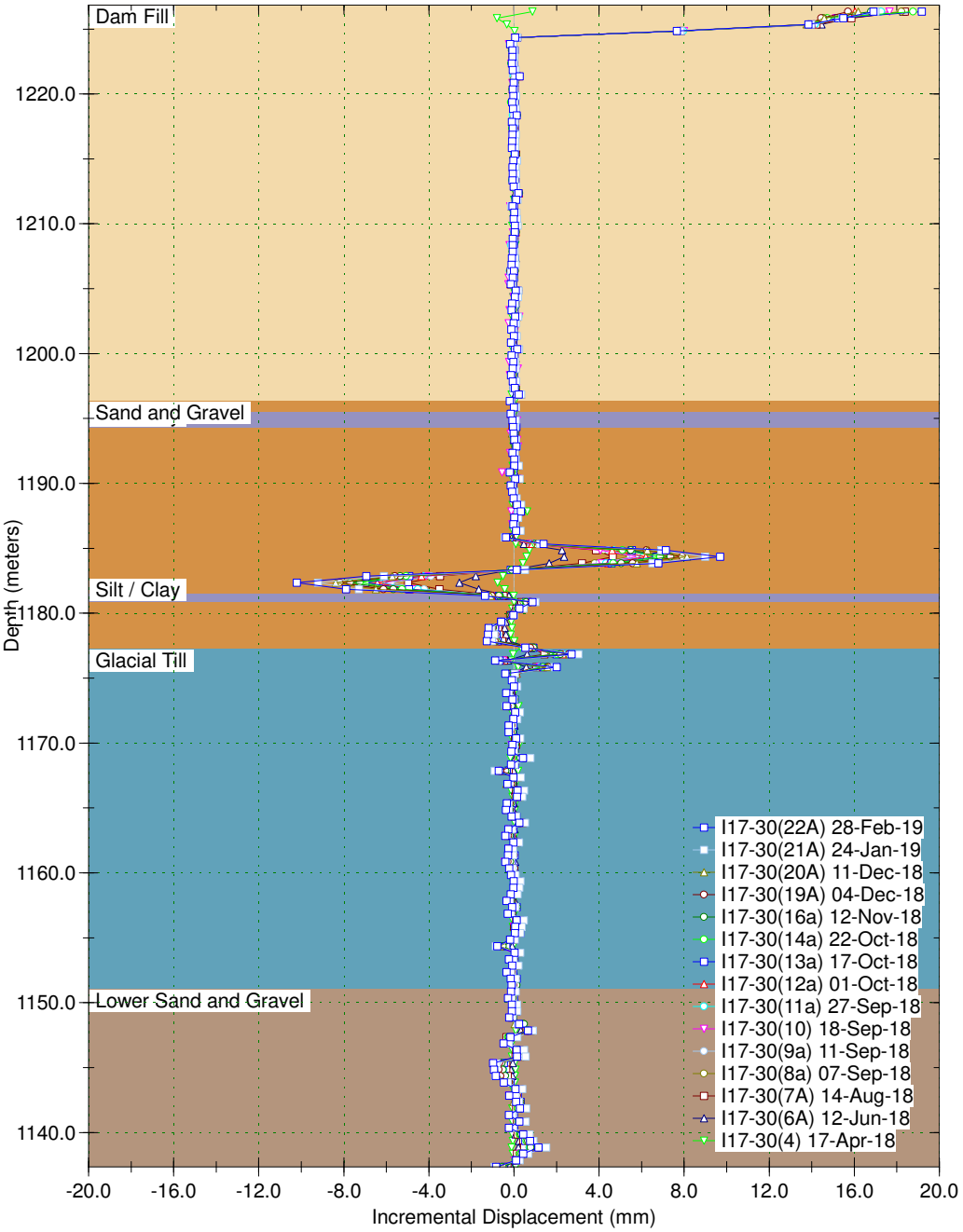
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

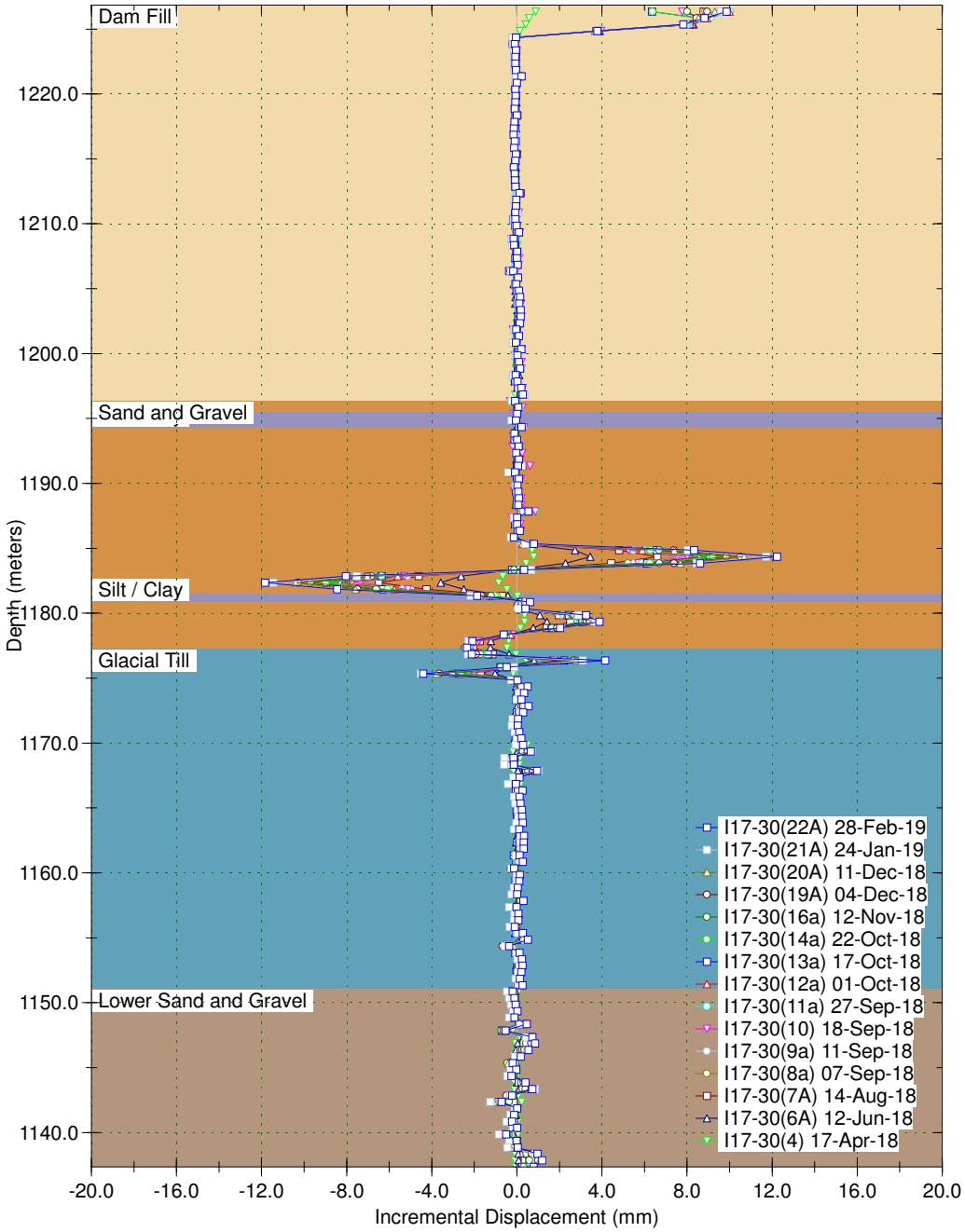
Borehole : I17-30
Project : HH Dam
Location :
Northing :
Easting :
Collar :

Spiral Correction : Enabled
Collar Elevation : :1226.85 meters
Reading Depth : 89.5 meters
A+ Groove Azimuth :
Base Reading : 2018 Mar 24 11:51
Applied Azimuth : 0.0 degrees

Axis - A



Axis - B



RST Instruments Ltd.

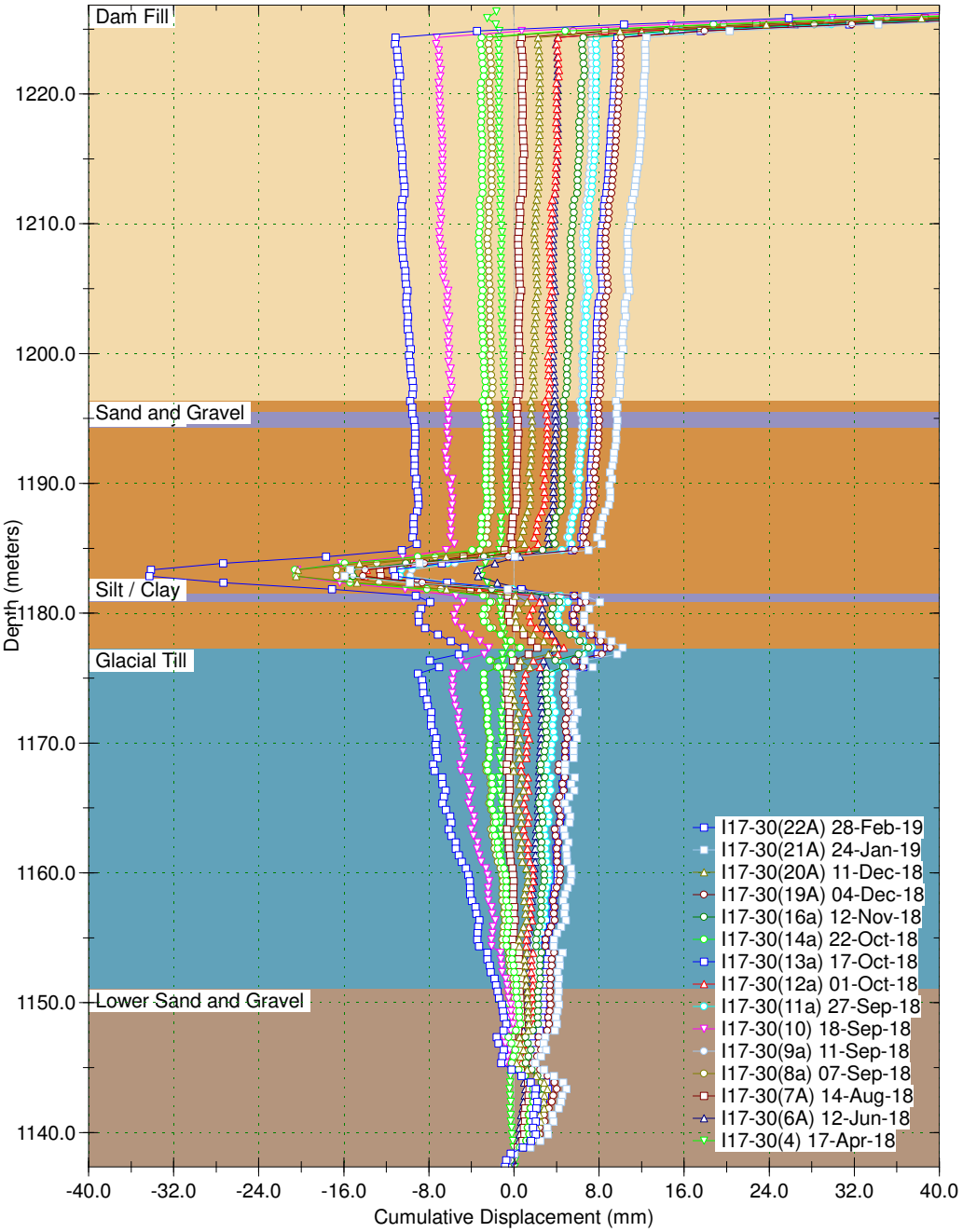
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

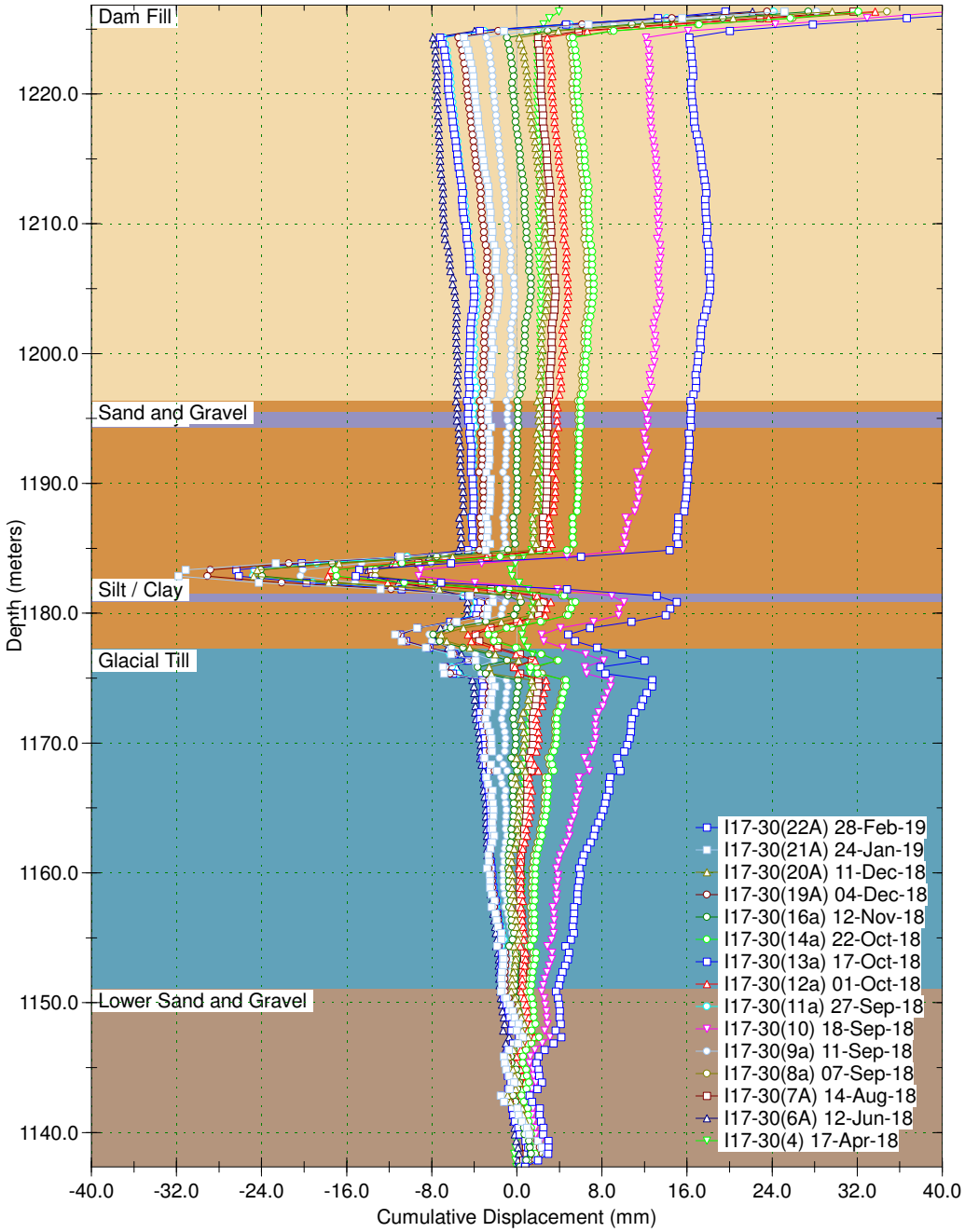
Borehole : I17-30
Project : HH Dam
Location :
Northing :
Easting :
Collar :

Spiral Correction : Enabled
Collar Elevation : :1226.85 meters
Reading Depth : 89.5 meters
A+ Groove Azimuth :
Base Reading : 2018 Mar 24 11:51
Applied Azimuth : 0.0 degrees

Axis - A



Axis - B



RST Instruments Ltd.

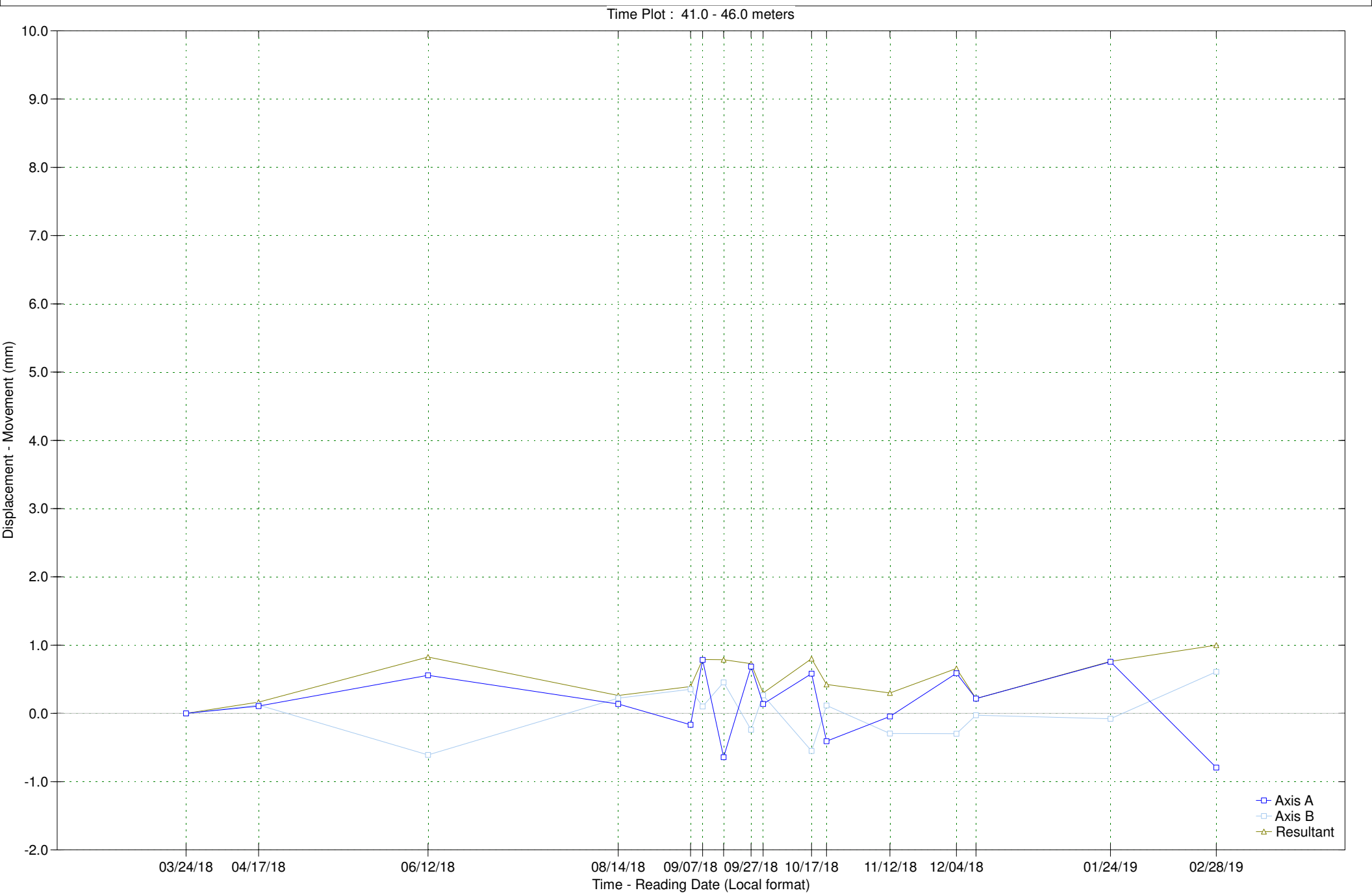
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I17-30
Project : HH Dam
Location :
Northing :
Easting :
Collar :
Collar Elev : 1226.85 meters

Spiral Correction : Enabled
Movement Depth : 41.0 - 46.0 meters
Reading Depth : 89.5 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 28 16:11
Initial Reading : 2018 Mar 24 11:51
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

TIME PLOT

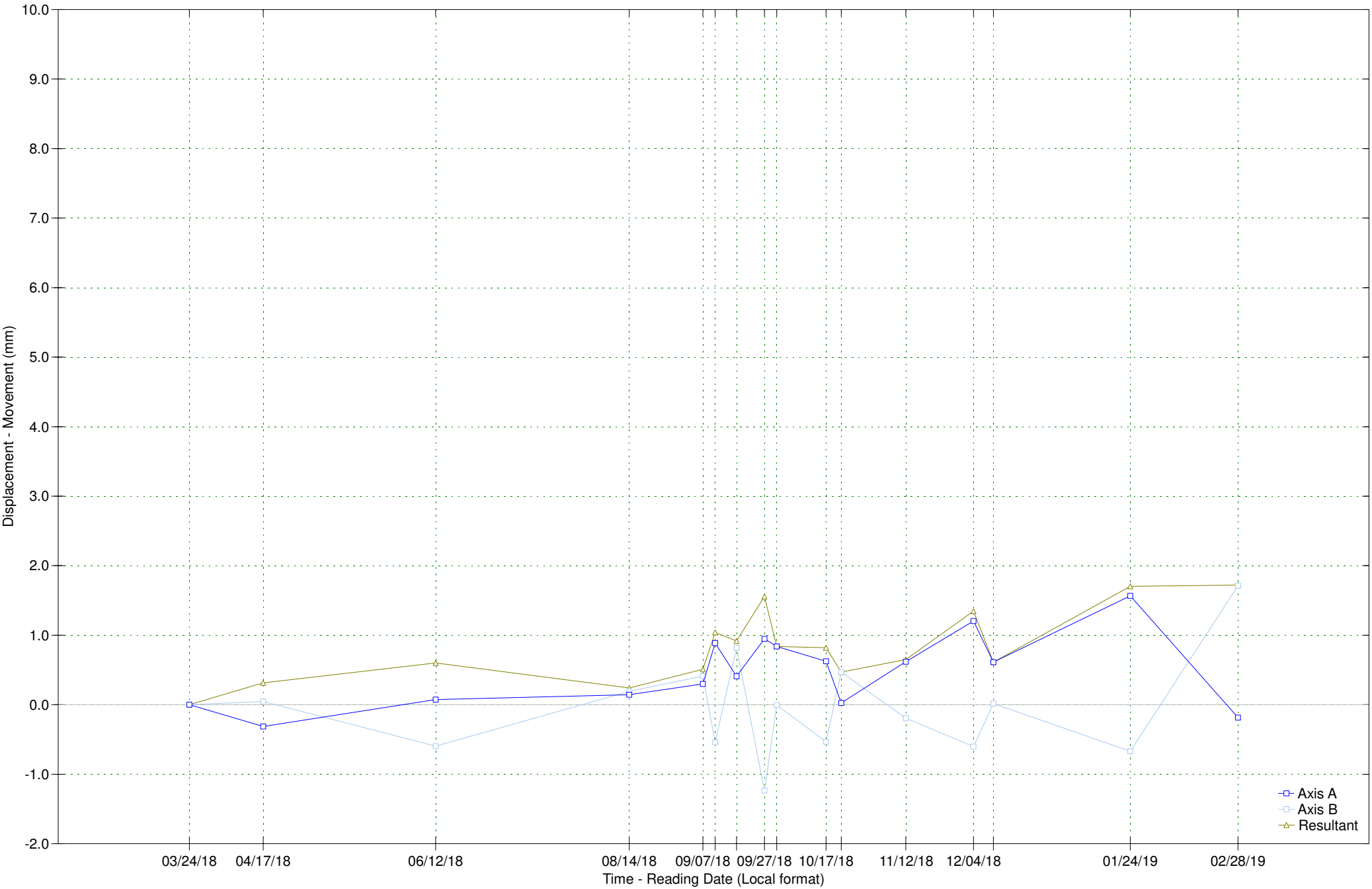
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : I17-30
Project : HH Dam
Location :
Northing :
Easting :
Collar :
Collar Elev : 1226.85 meters

Spiral Correction : Enabled
Movement Depth : 46.5 - 52.0 meters
Reading Depth : 89.5 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 28 16:11
Initial Reading : 2018 Mar 24 11:51
Applied Azimuth : 0.0 degrees

Time Plot : 46.5 - 52.0 meters



H-H DAM

HH I17-31

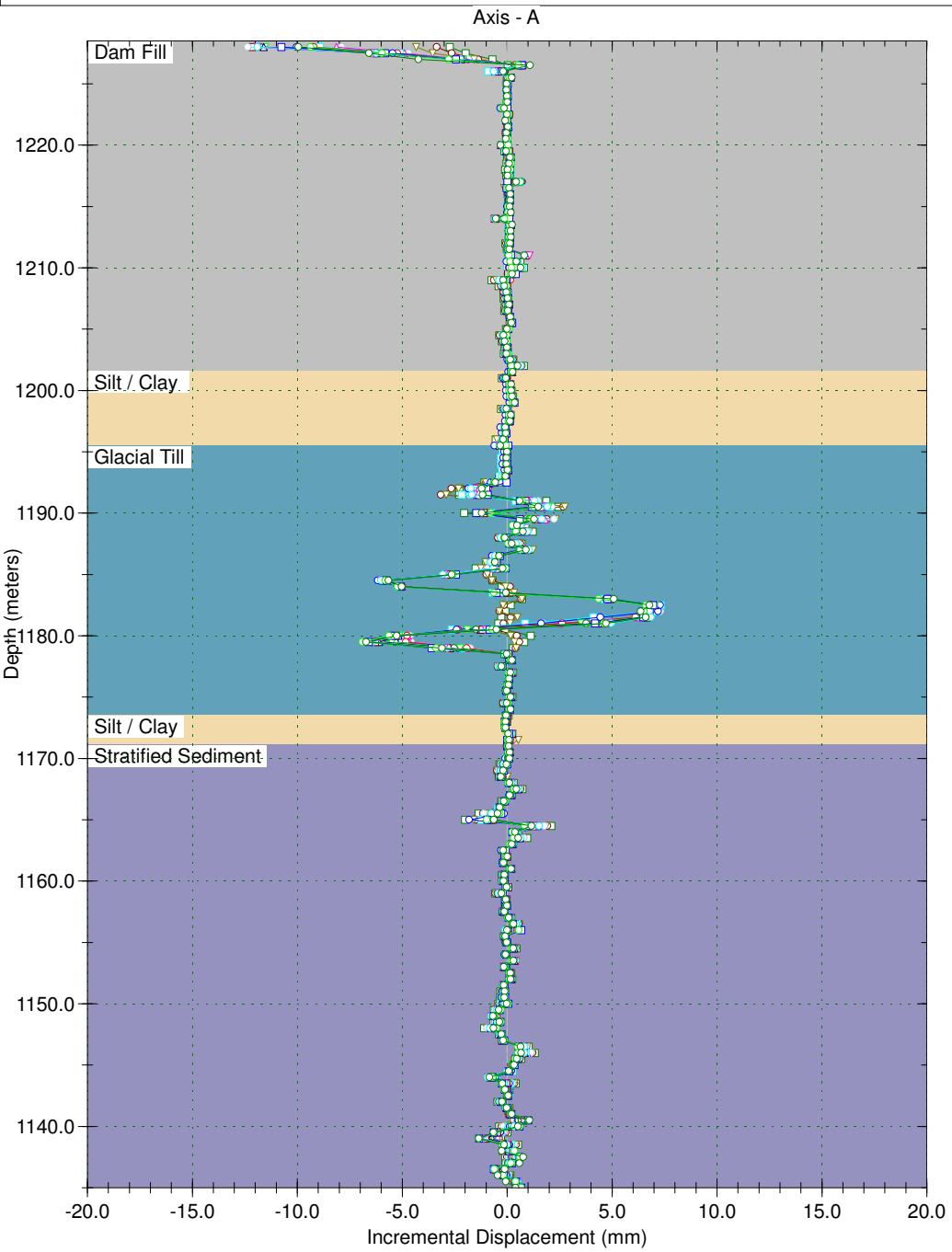
RST Instruments Ltd.

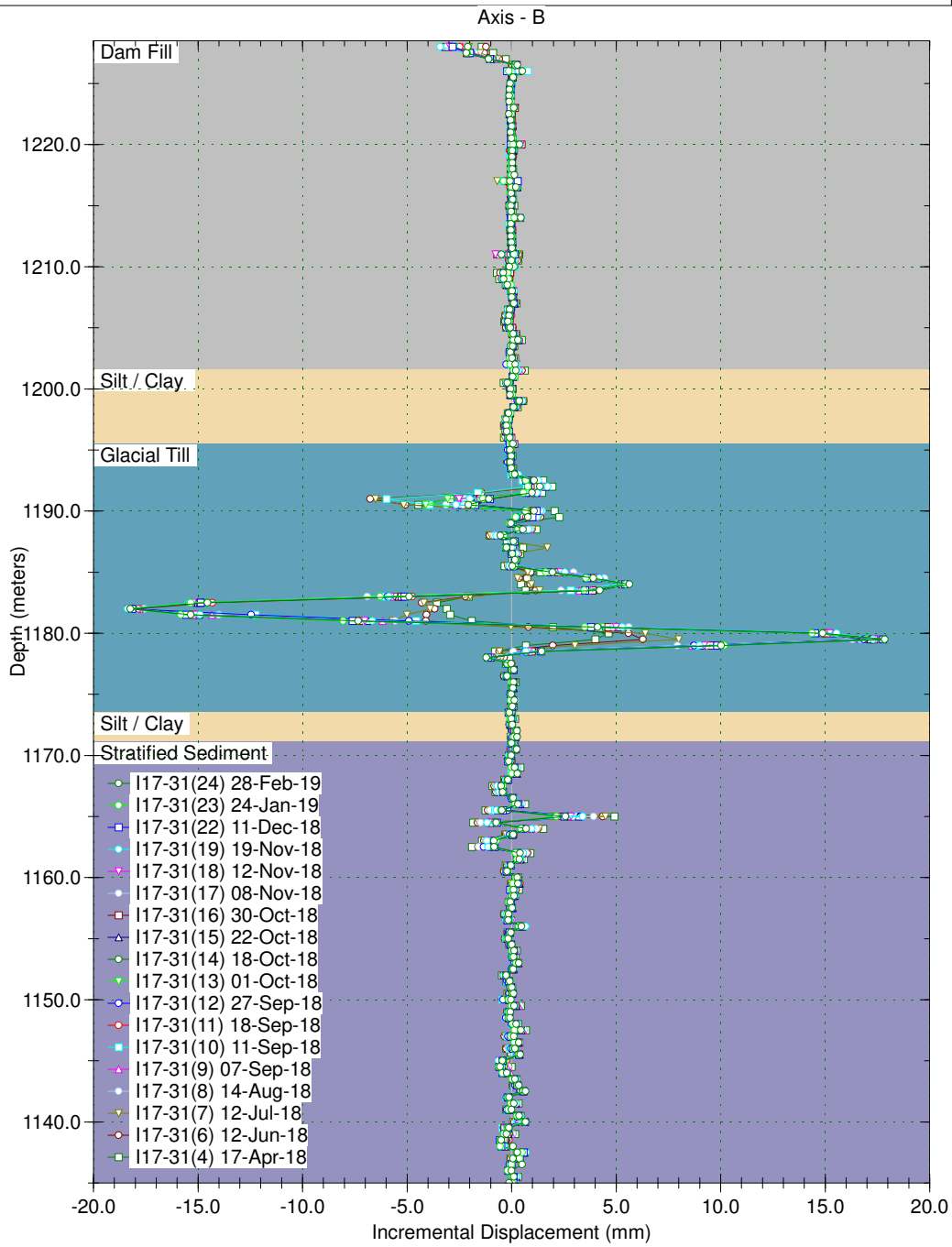
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-31
Location :
Northing :
Easting :
Collar :

Spiral Correction : Enabled
Collar Elevation : :1228.50 meters
Reading Depth : 94.0 meters
A+ Groove Azimuth :
Base Reading : 2018 Mar 01 10:54
Applied Azimuth : 0.0 degrees





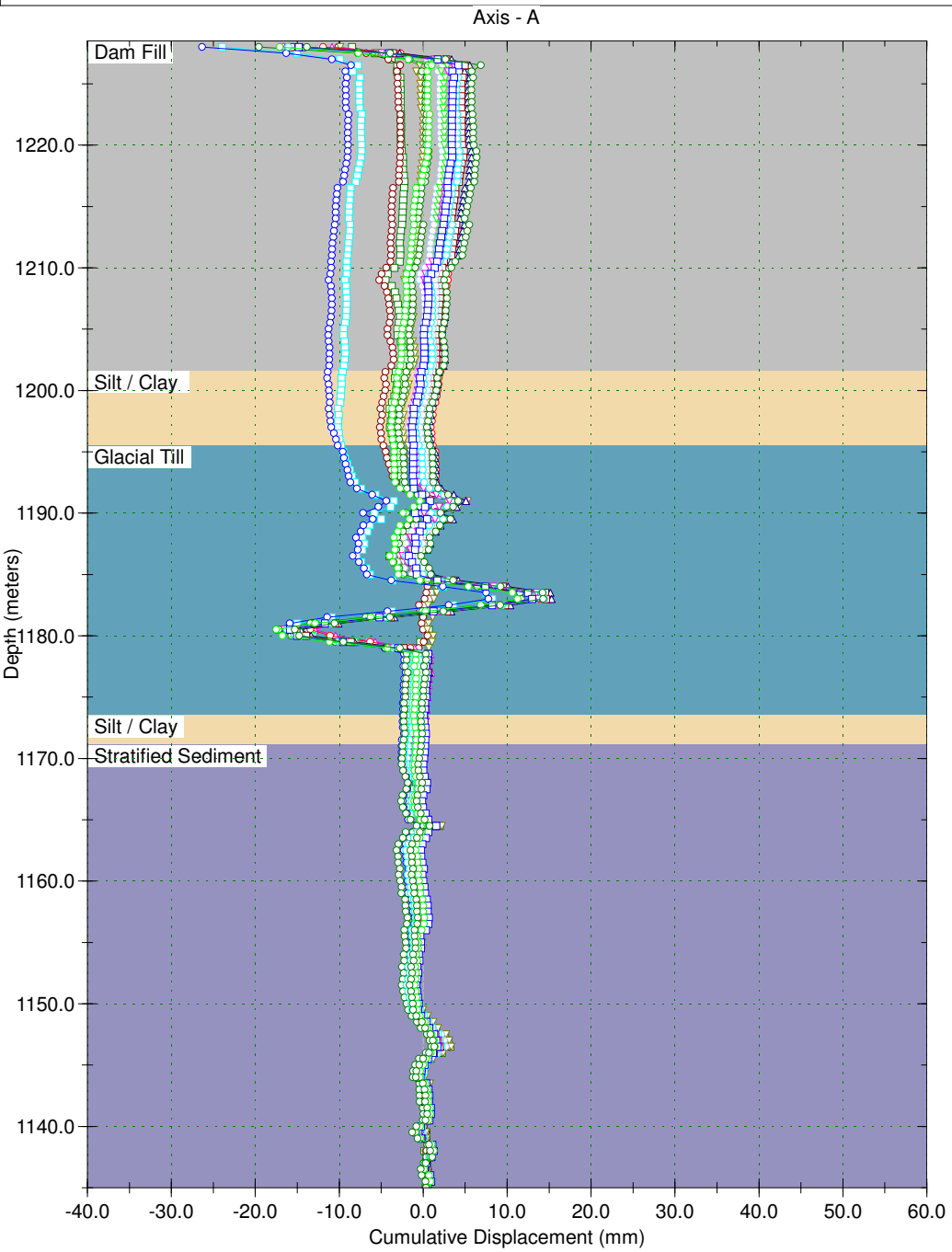
RST Instruments Ltd.

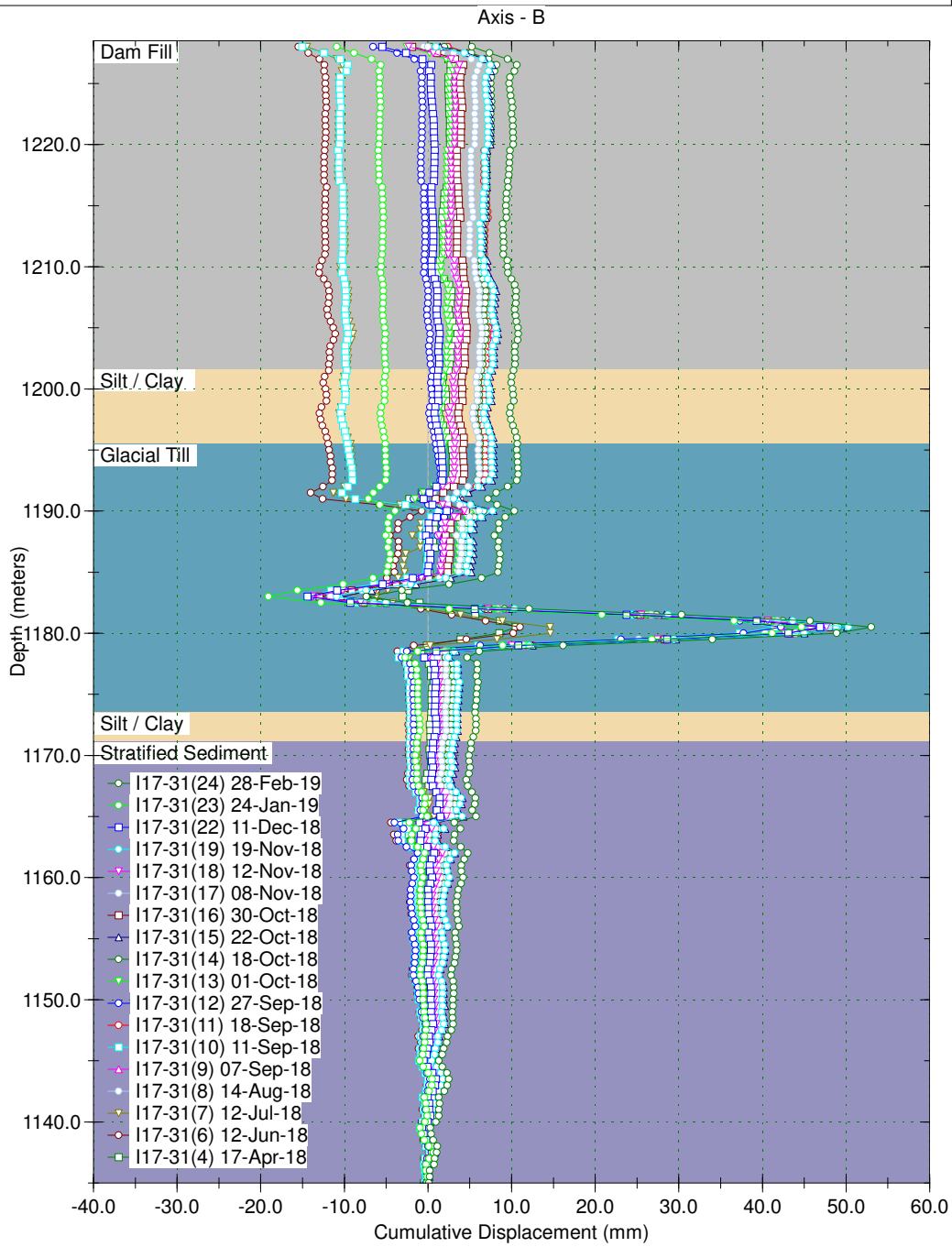
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-31
Location :
Northing :
Easting :
Collar :

Spiral Correction : Enabled
Collar Elevation : :1228.50 meters
Reading Depth : 94.0 meters
A+ Groove Azimuth :
Base Reading : 2018 Mar 01 10:54
Applied Azimuth : 0.0 degrees





RST Instruments Ltd.

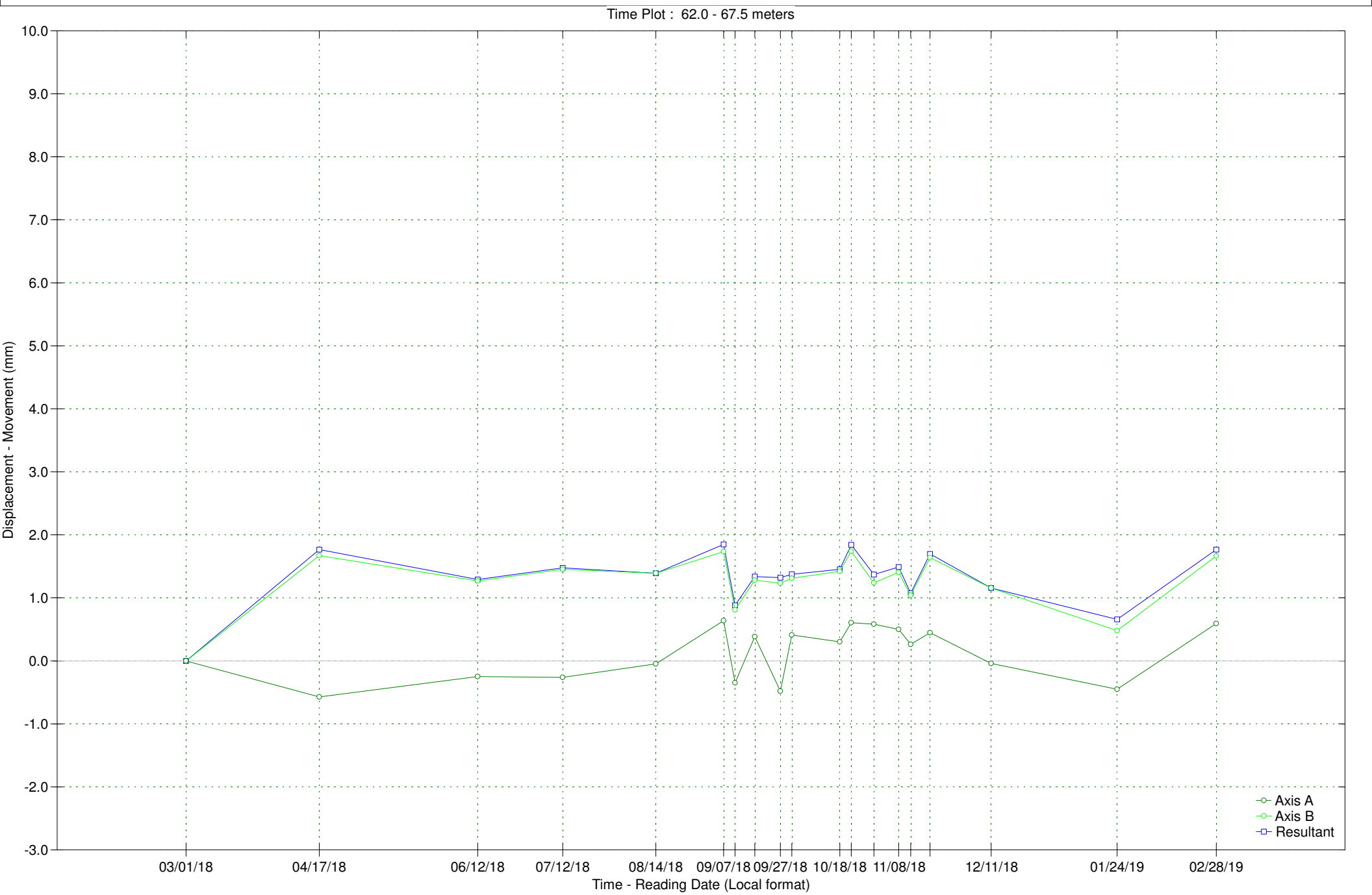
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-31
Location :
Northing :
Easting :
Collar :
Collar Elev : 1228.50 meters

Spiral Correction : Enabled
Movement Depth : 62.0 - 67.5 meters
Reading Depth : 94.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 28 14:52
Initial Reading : 2018 Mar 01 10:54
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

TIME PLOT

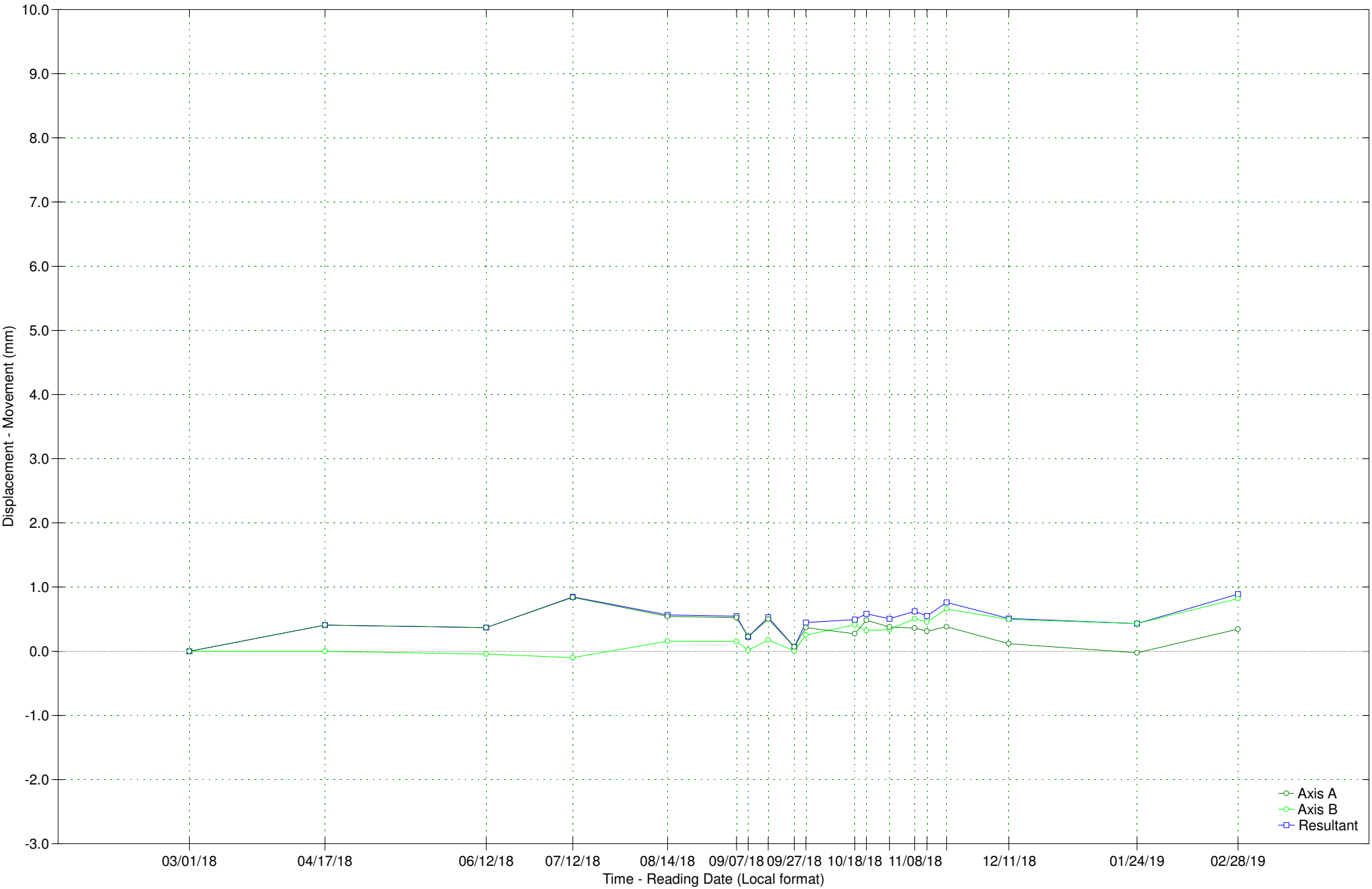
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-31
Location :
Northing :
Easting :
Collar :
Collar Elev : 1228.50 meters

Spiral Correction : Enabled
Movement Depth : 55.5 - 58.5 meters
Reading Depth : 94.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 28 14:52
Initial Reading : 2018 Mar 01 10:54
Applied Azimuth : 0.0 degrees

Time Plot : 55.5 - 58.5 meters



RST Instruments Ltd.

TIME PLOT

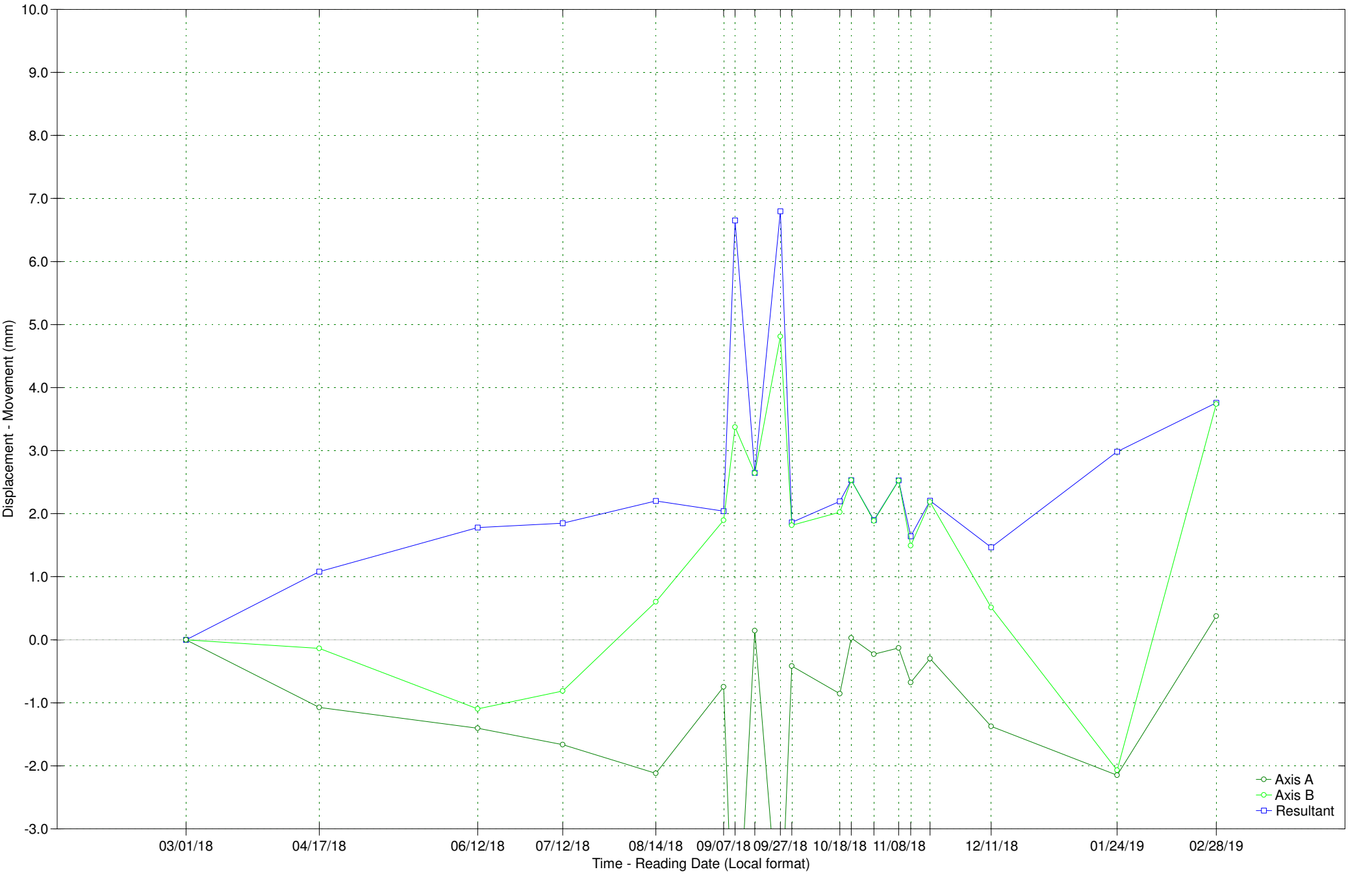
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-31
Location :
Northing :
Easting :
Collar :
Collar Elev : 1228.50 meters

Spiral Correction : Enabled
Movement Depth : 43.0 - 50.0 meters
Reading Depth : 94.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 28 14:52
Initial Reading : 2018 Mar 01 10:54
Applied Azimuth : 0.0 degrees

Time Plot : 43.0 - 50.0 meters



RST Instruments Ltd.

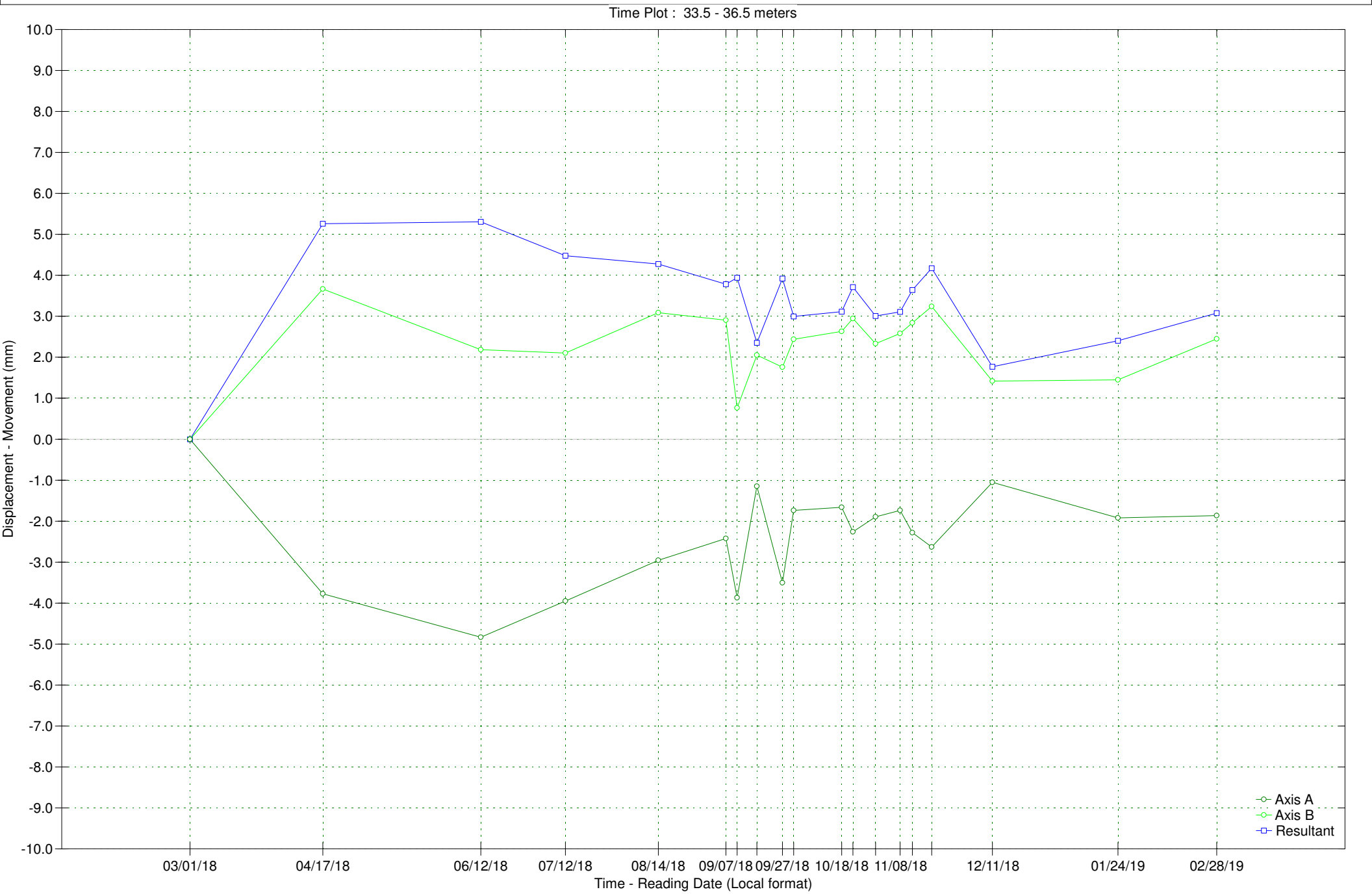
TIME PLOT

Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-31
Location :
Northing :
Easting :
Collar :
Collar Elev : 1228.50 meters

Spiral Correction : Enabled
Movement Depth : 33.5 - 36.5 meters
Reading Depth : 94.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 28 14:52
Initial Reading : 2018 Mar 01 10:54
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

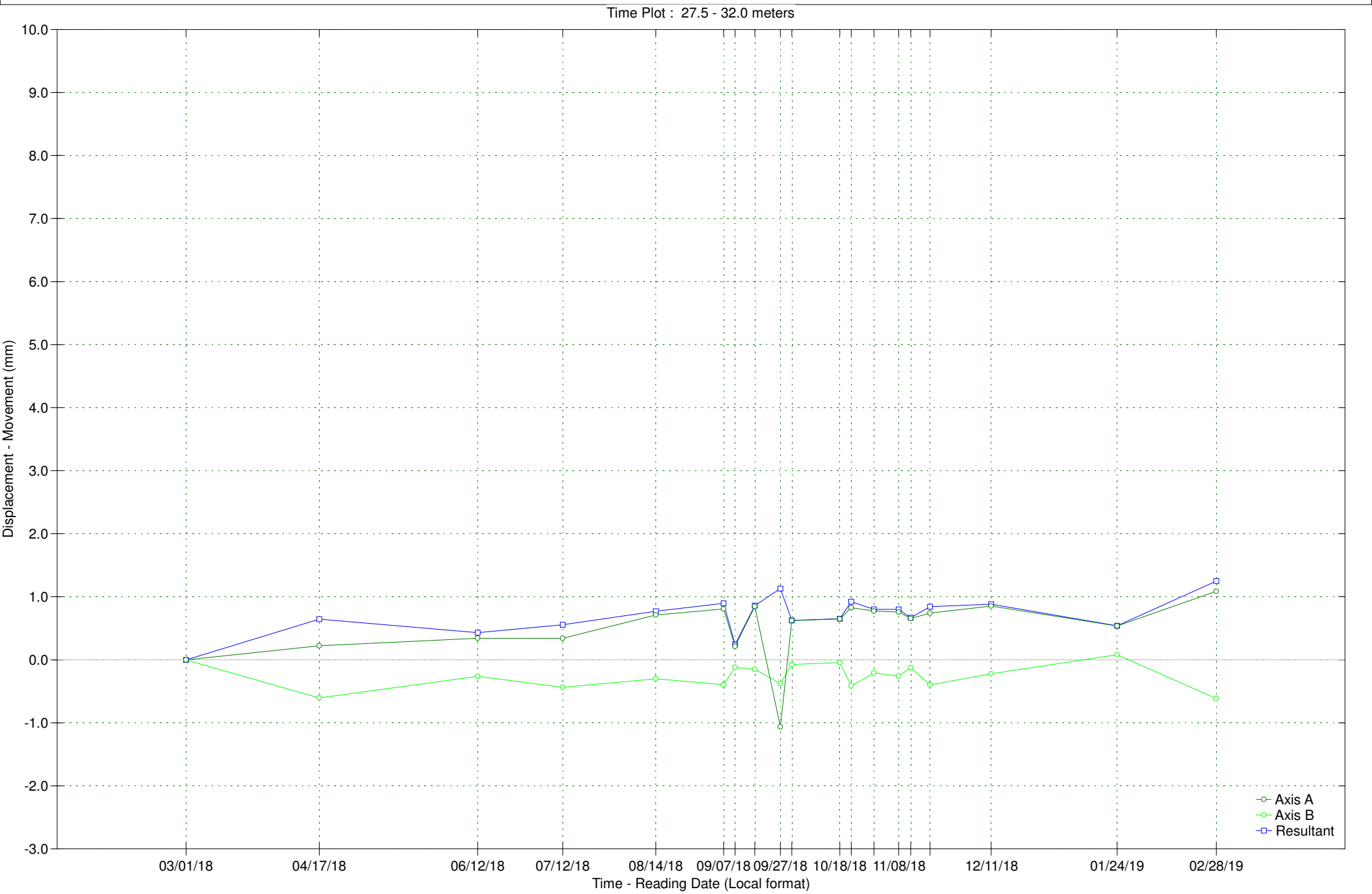
TIME PLOT

Displacement vs. Time

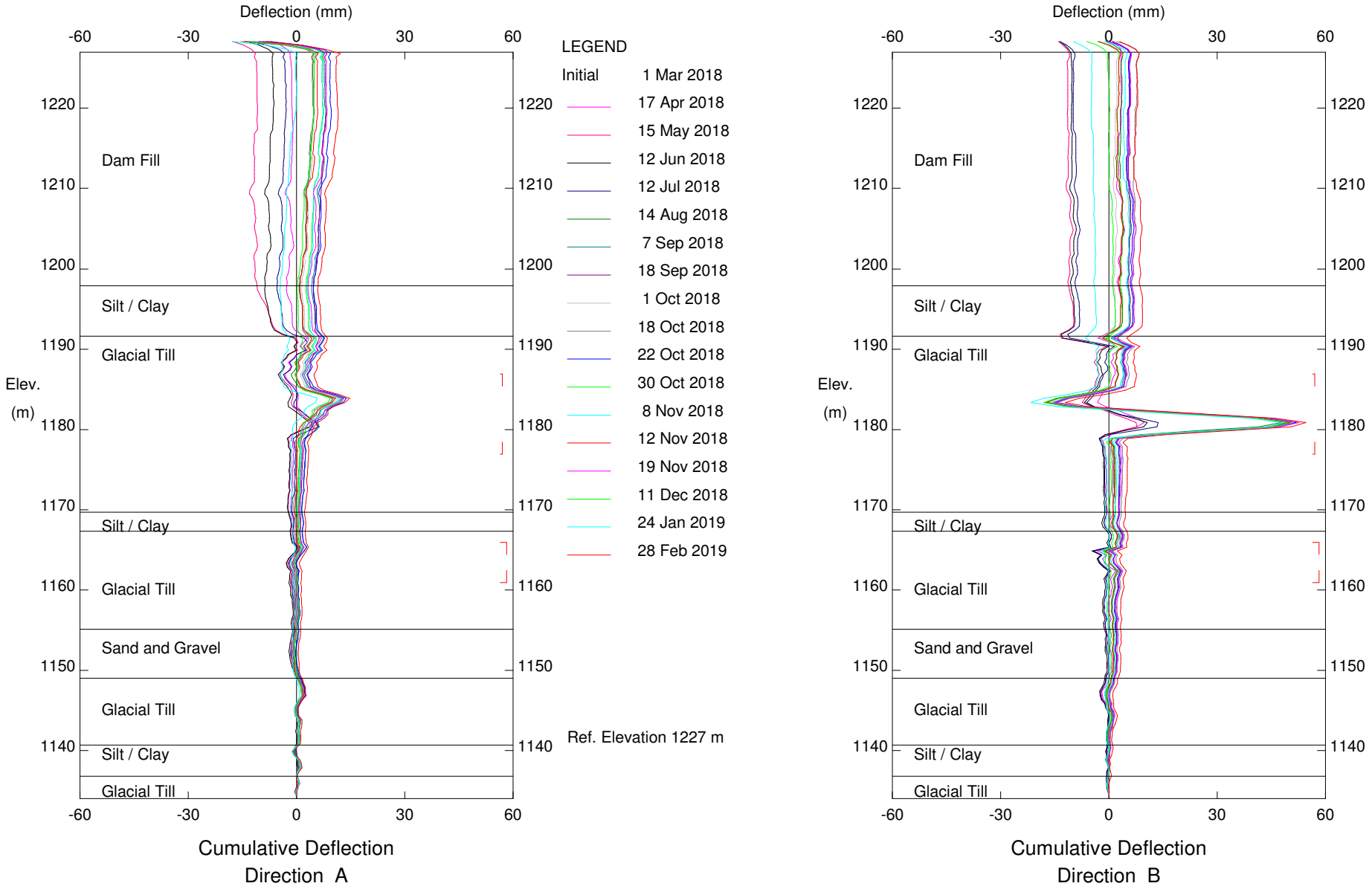
Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-31
Location :
Northing :
Easting :
Collar :
Collar Elev : 1228.50 meters

Spiral Correction : Enabled
Movement Depth : 27.5 - 32.0 meters
Reading Depth : 94.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Feb 28 14:52
Initial Reading : 2018 Mar 01 10:54
Applied Azimuth : 0.0 degrees



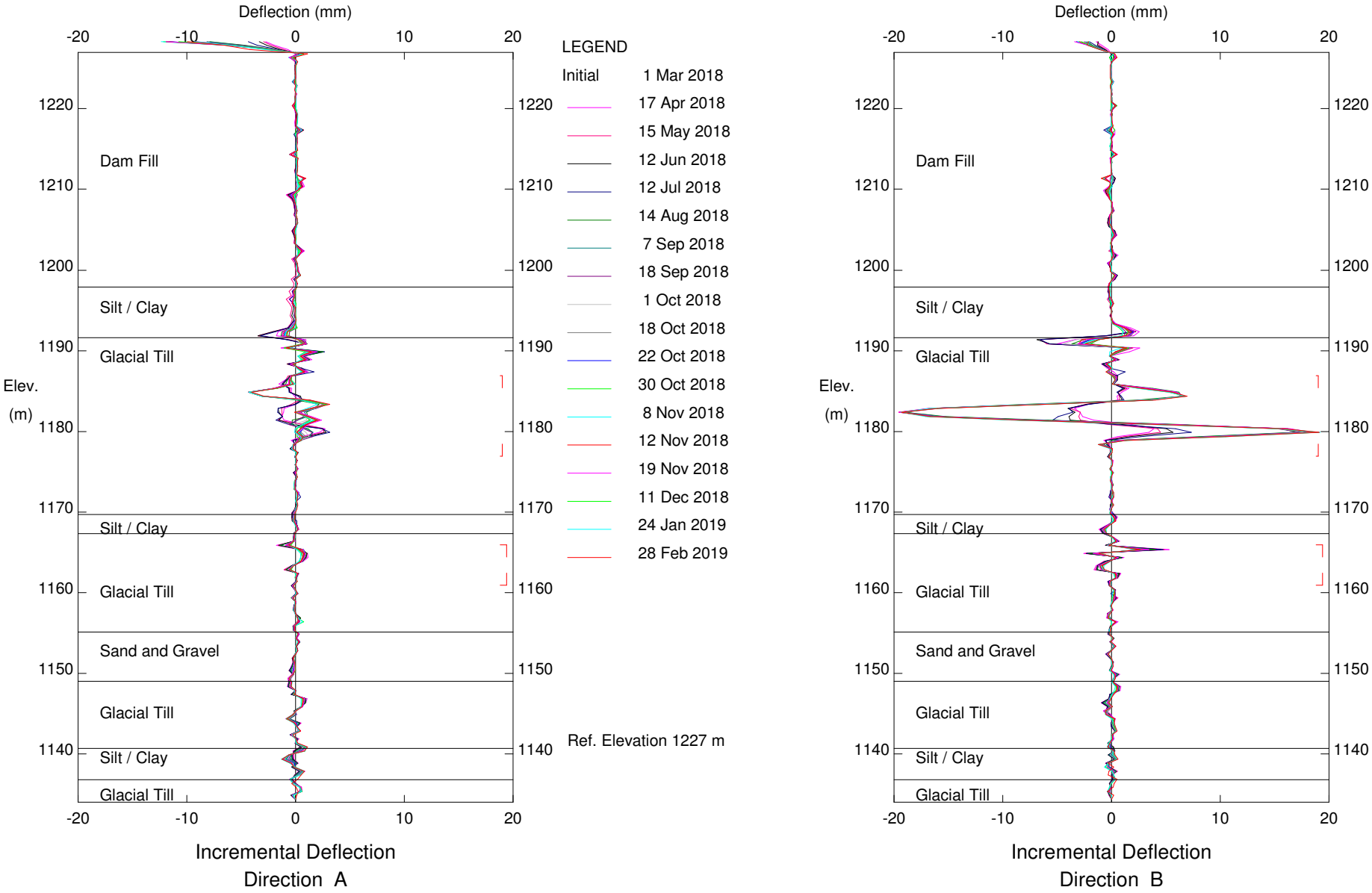
Highland Valley Copper - Logan Lake, BC



H-H Dam, Inclinometer I17-31

V:\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\H-H Dam\SI Monitoring\HH Dam\I17-31\GTILT\I17-31.gtl

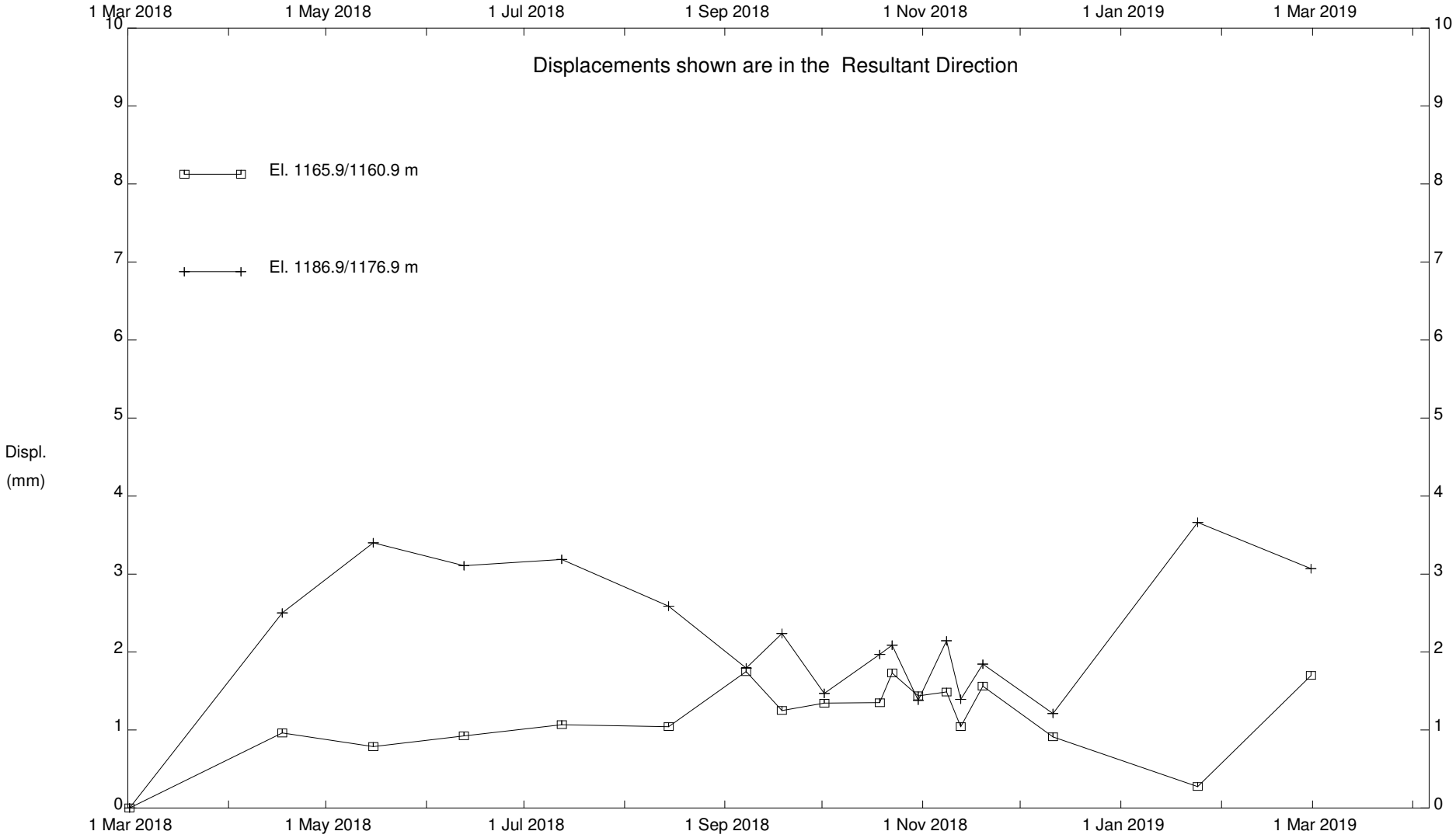
Highland Valley Copper - Logan Lake, BC



H-H Dam, Inclinometer I17-31

V:\03 CIVIL GROUP\01 Dam Management\09 Geotechnical\Instrumentation\Dam Movement Monitoring\H-H Dam\SI Monitoring\HH Dam\I17-31\GTILT\I17-31.gtl

Highland Valley Copper - Logan Lake, BC



H-H Dam, Inclinometer I17-31

H-H DAM

HH I17-33

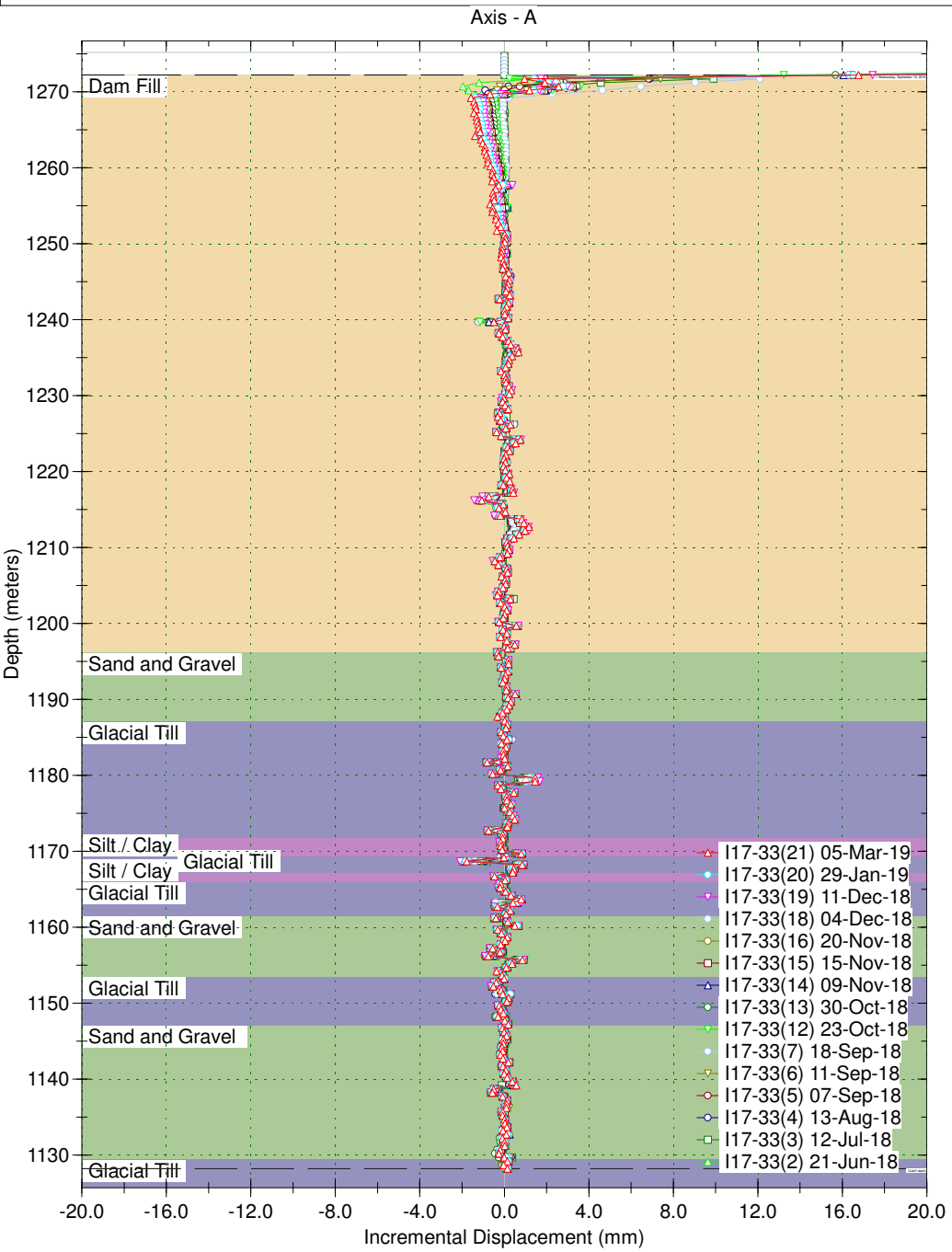
RST Instruments Ltd.

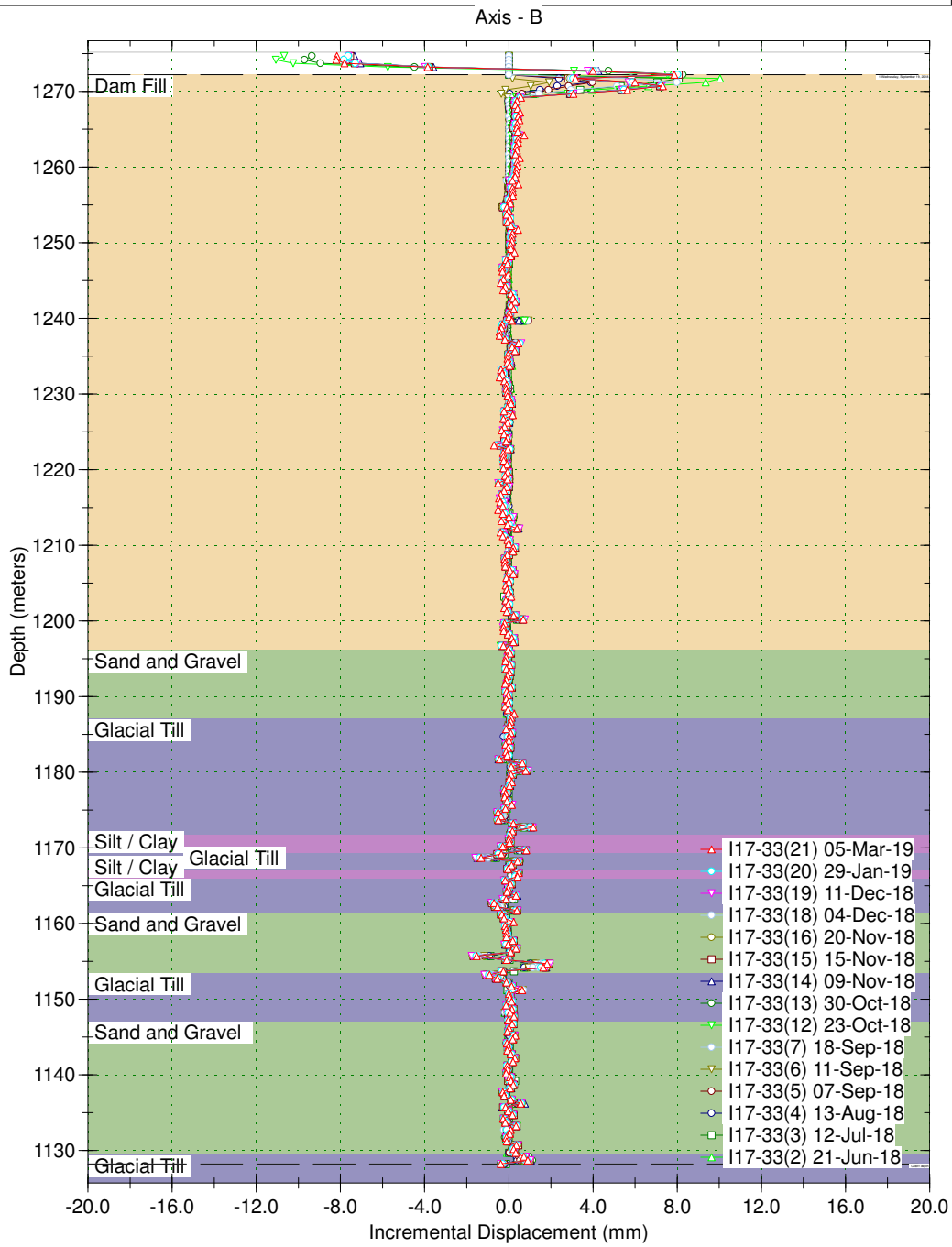
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-33
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1275.20 meters
Reading Depth : 144.0 meters
A+ Groove Azimuth :
Base Reading : 2018 May 15 10:33
Applied Azimuth : 0.0 degrees





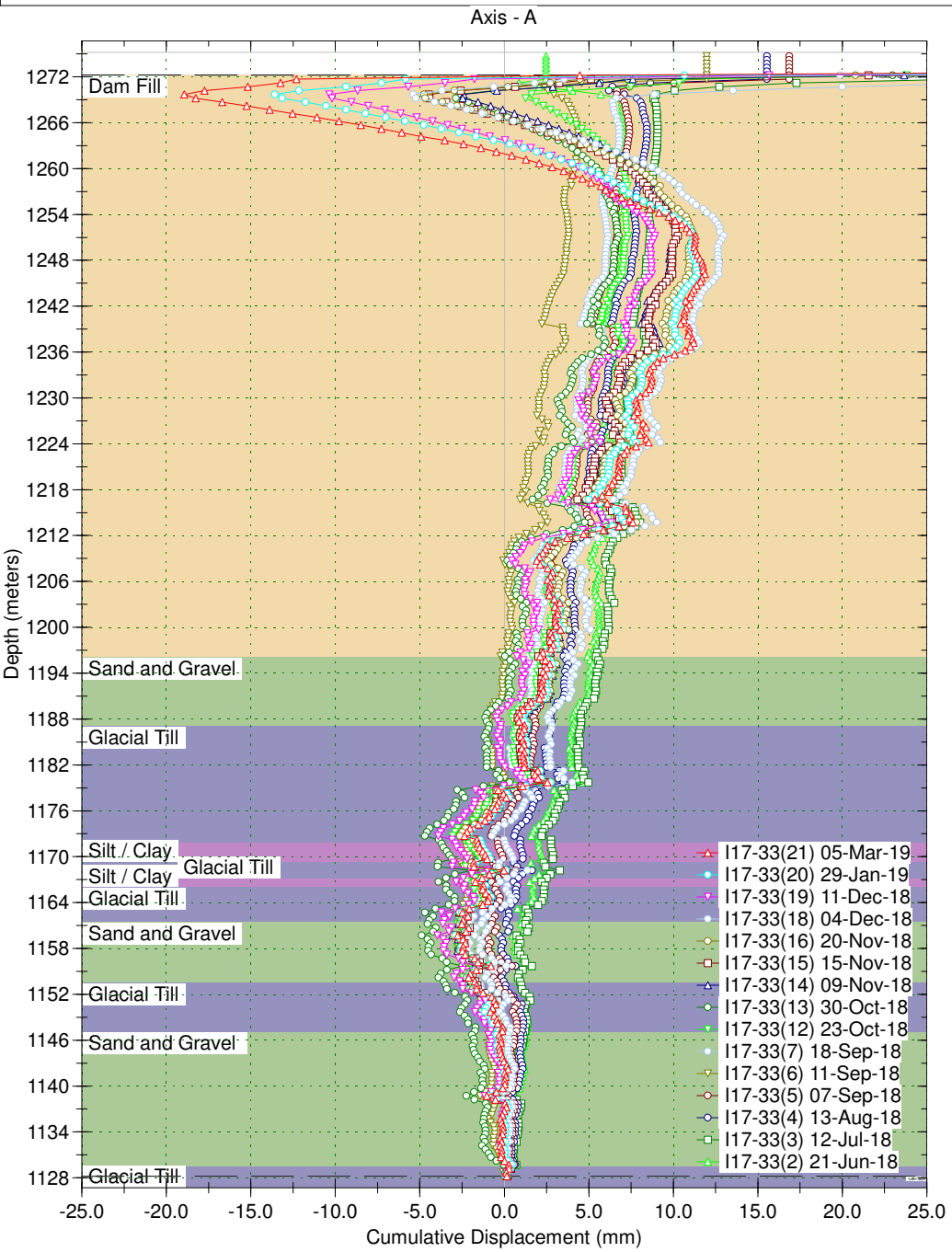
RST Instruments Ltd.

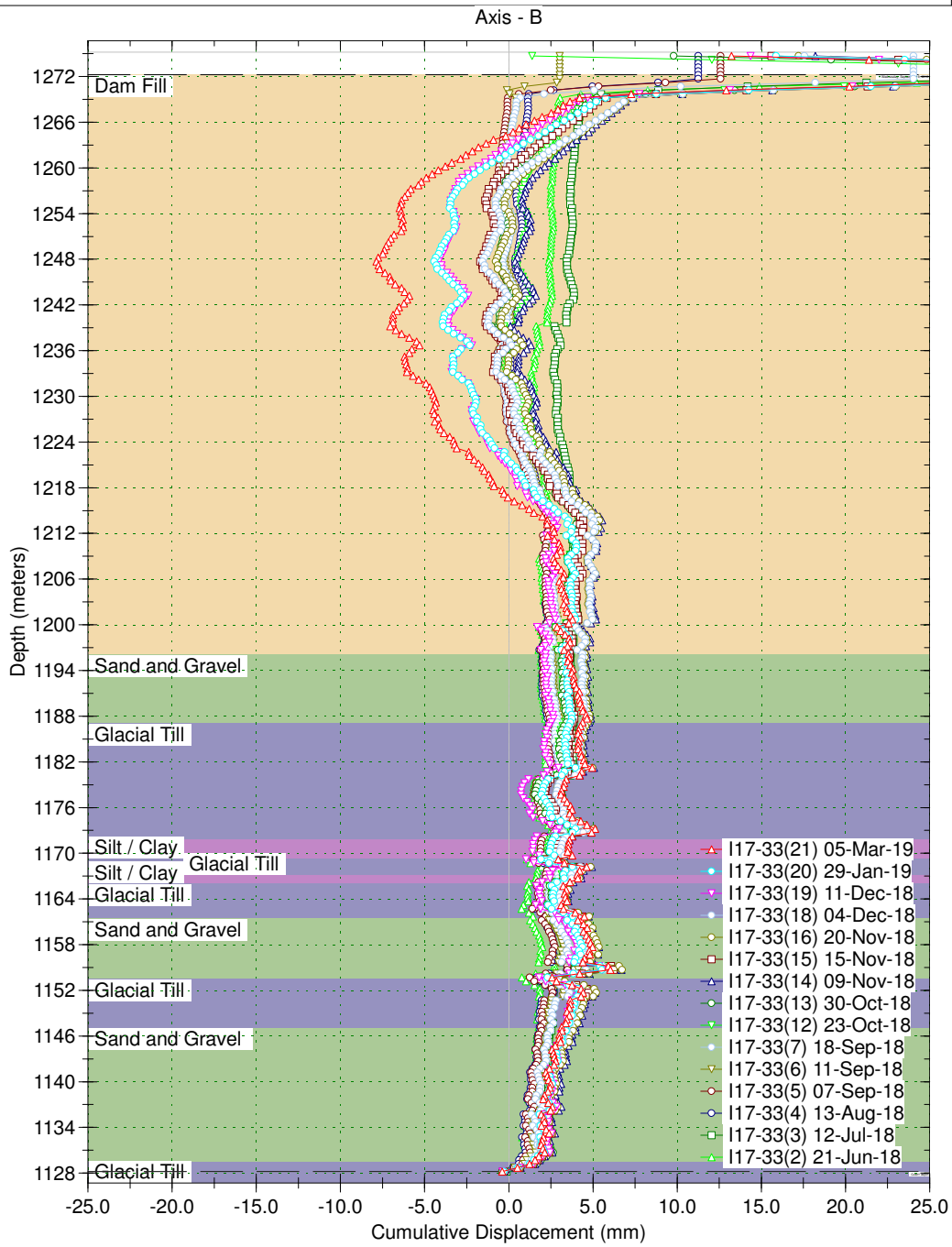
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-33
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : :1275.20 meters
Reading Depth : 144.0 meters
A+ Groove Azimuth :
Base Reading : 2018 May 15 10:33
Applied Azimuth : 0.0 degrees





RST Instruments Ltd.

TIME PLOT

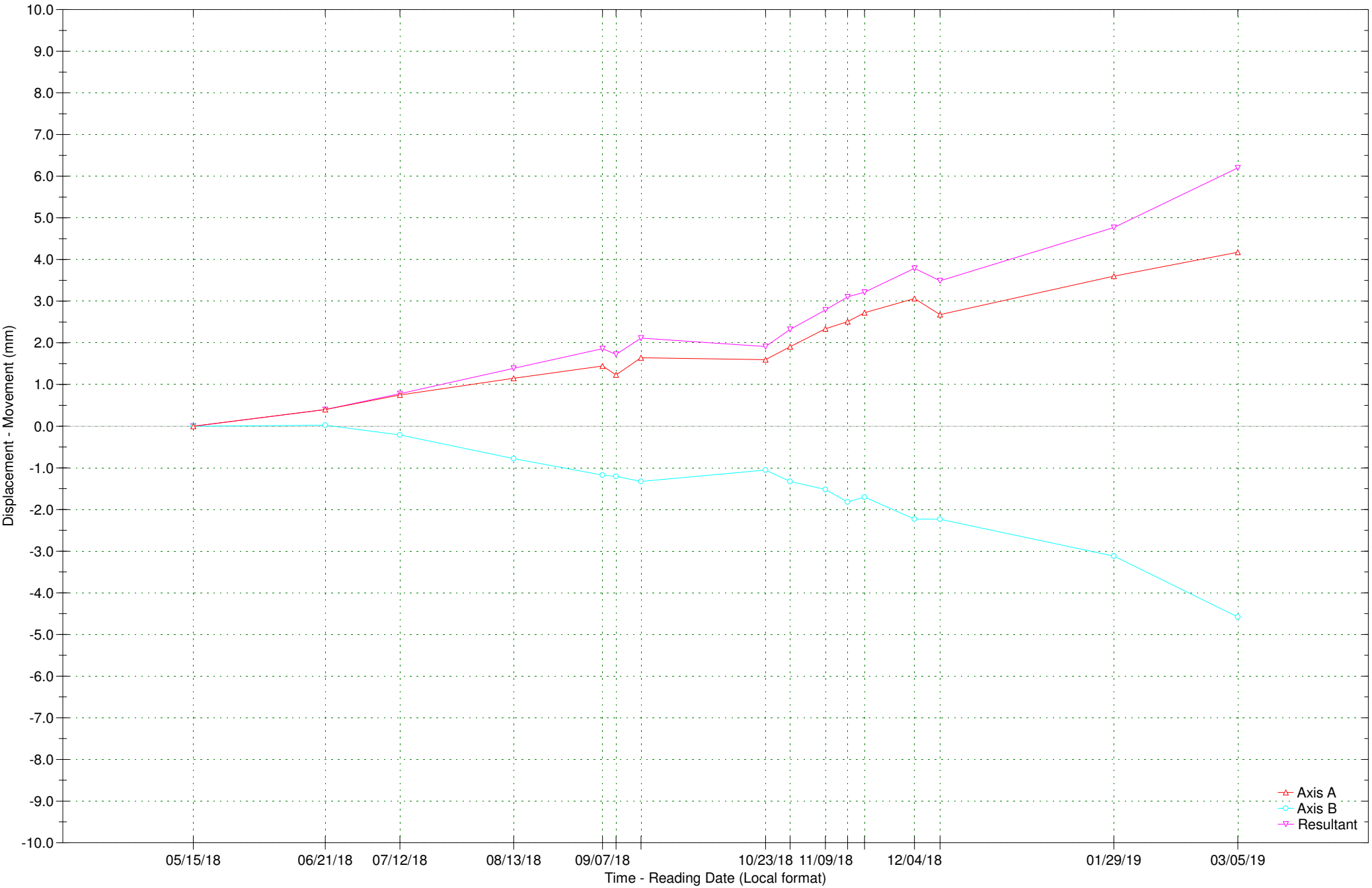
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-33
Location :
Northing :
Easting :
Collar :
Collar Elev : 1275.20 meters

Spiral Correction : N/A
Movement Depth : 55.0 - 70.0 meters
Reading Depth : 147.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Mar 05 10:58
Initial Reading : 2018 May 15 10:33
Applied Azimuth : 0.0 degrees

Time Plot : 55.0 - 70.0 meters



RST Instruments Ltd.

TIME PLOT

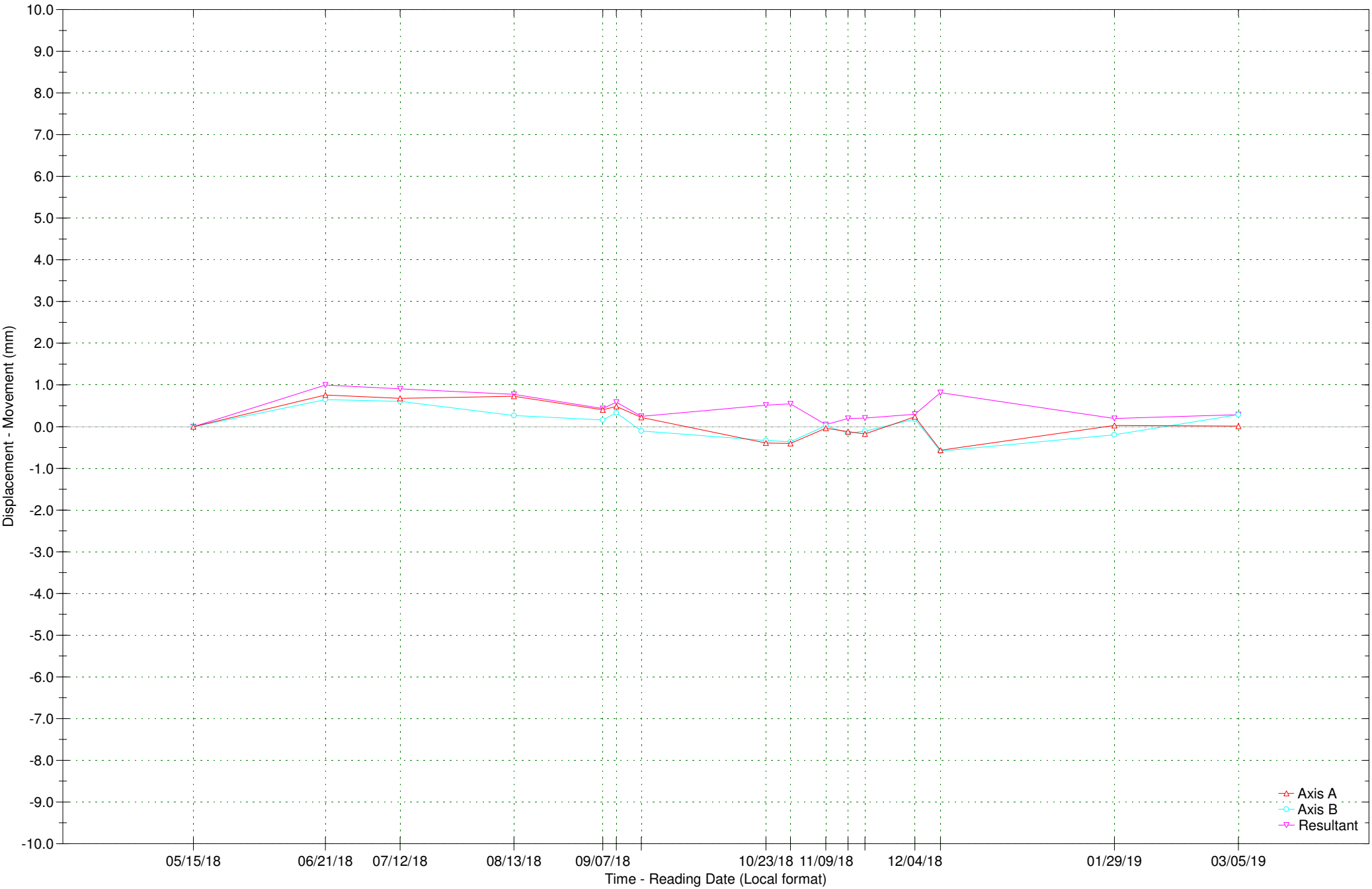
Displacement vs. Time

Inclinalysis v. 2.48.7

Borehole : RMR
Project : I17-33
Location :
Northing :
Easting :
Collar :
Collar Elev : 1275.20 meters

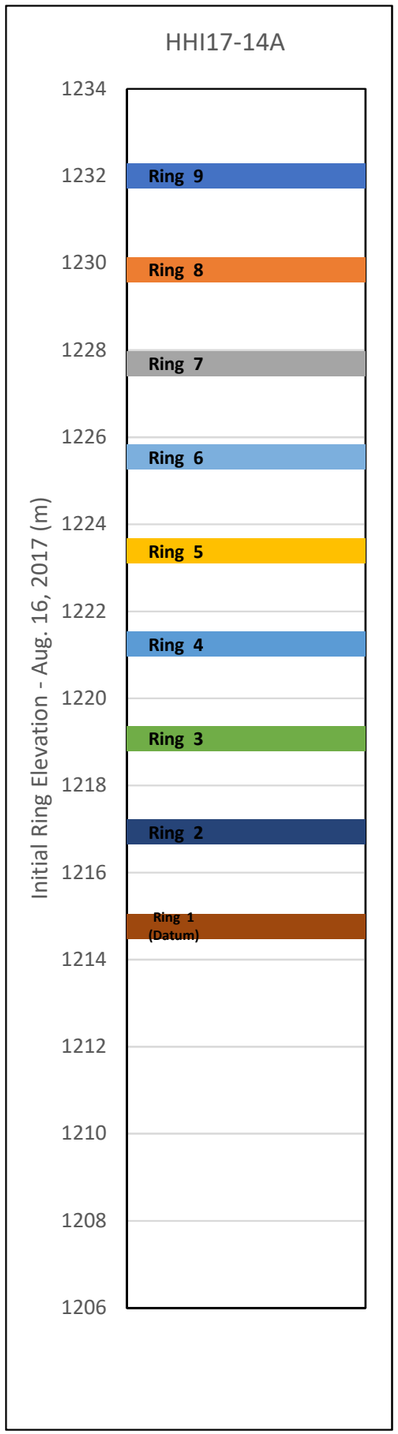
Spiral Correction : N/A
Movement Depth : 100.0 - 110.0 meters
Reading Depth : 147.0 meters
A+ Groove Azimuth :
Latest Reading : 2019 Mar 05 10:58
Initial Reading : 2018 May 15 10:33
Applied Azimuth : 0.0 degrees

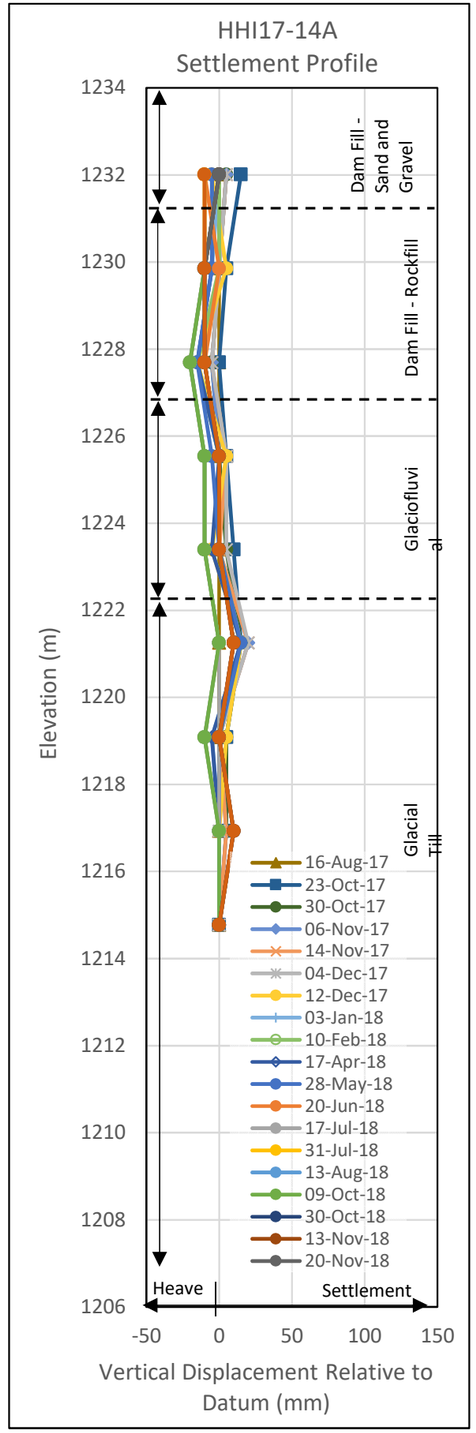
Time Plot : 100.0 - 110.0 meters

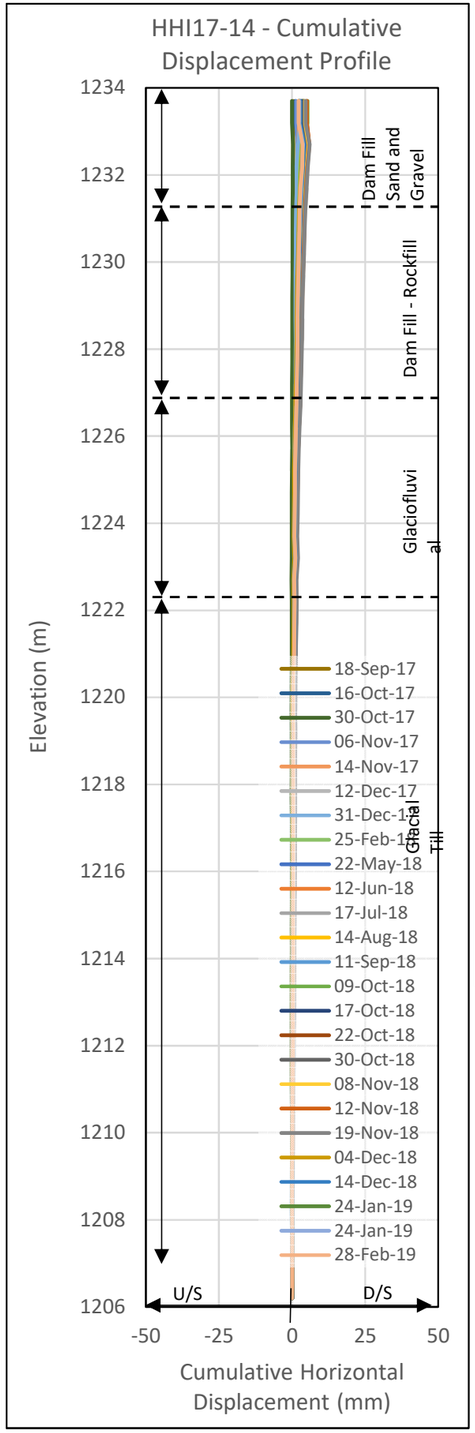


H-H DAM

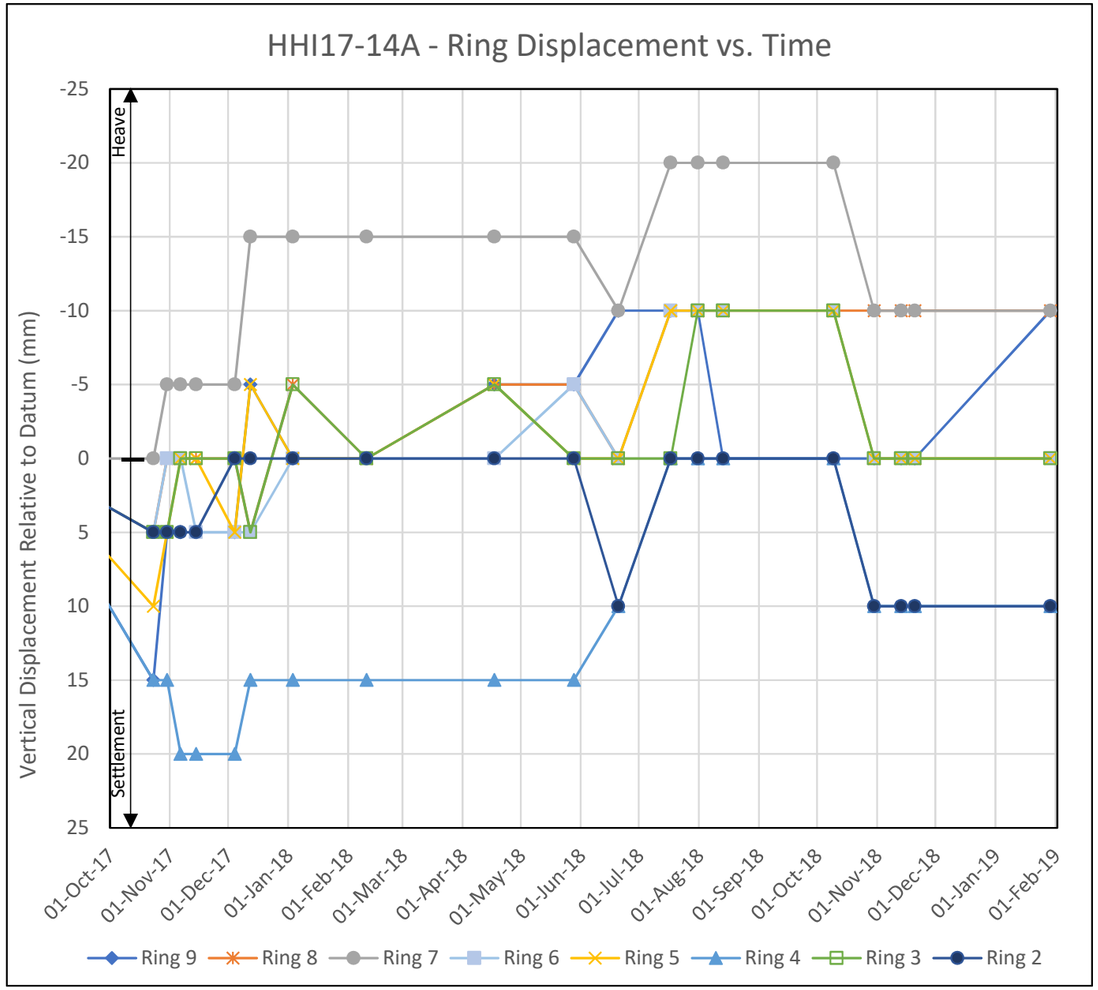
HH SONDEX







Note: Baseline reading is September 18, 2017



Notes:

1. Ring displacements are calculated relative to the initial elevations for each ring. The datum is the bottom ring (Ring 1).
2. Positive displacements represent settlement. Negative displacements represent heave.
3. The Ring 4 reading from February 10, 2018 was not consistent with readings in the rings above and below, due to a suspected data entry error. The reading was adjusted to match the trends of Ring 3 and Ring 5.

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TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

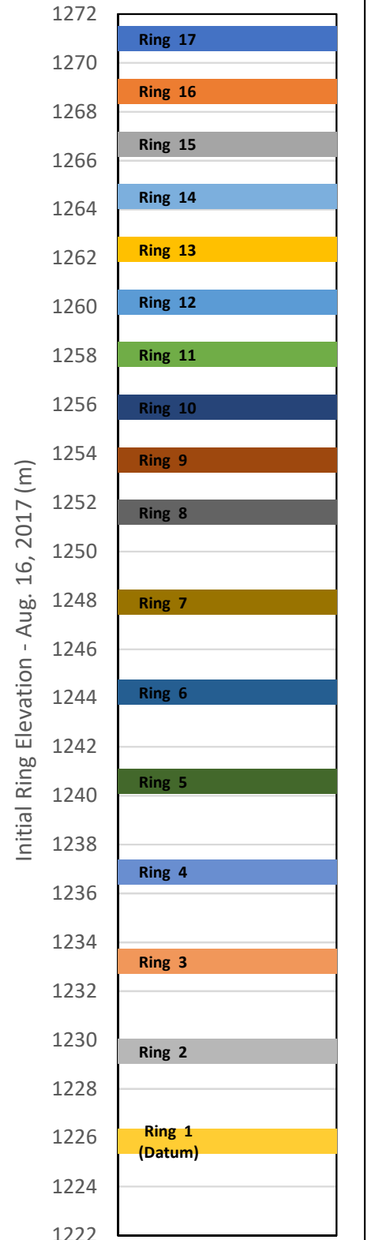
HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

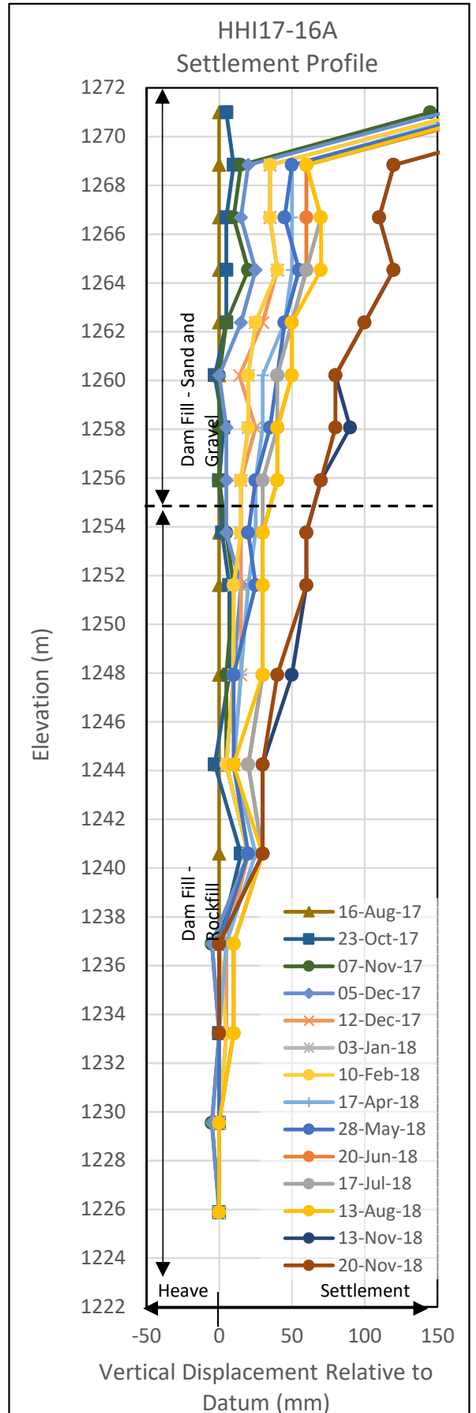
H-H Dam Vertical Displacements - HHI17-14A (Sondex)

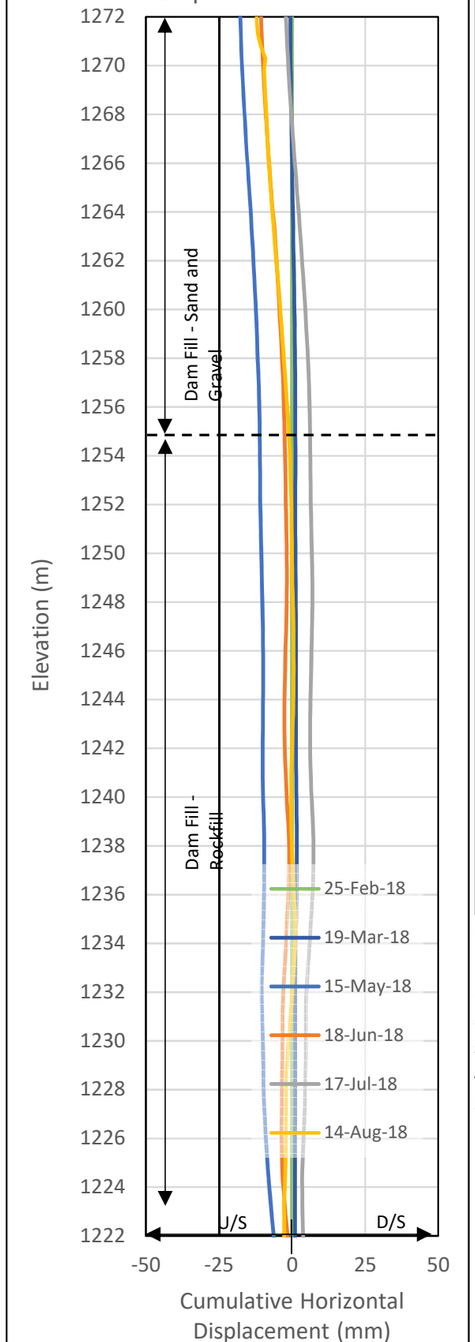
M02341B43

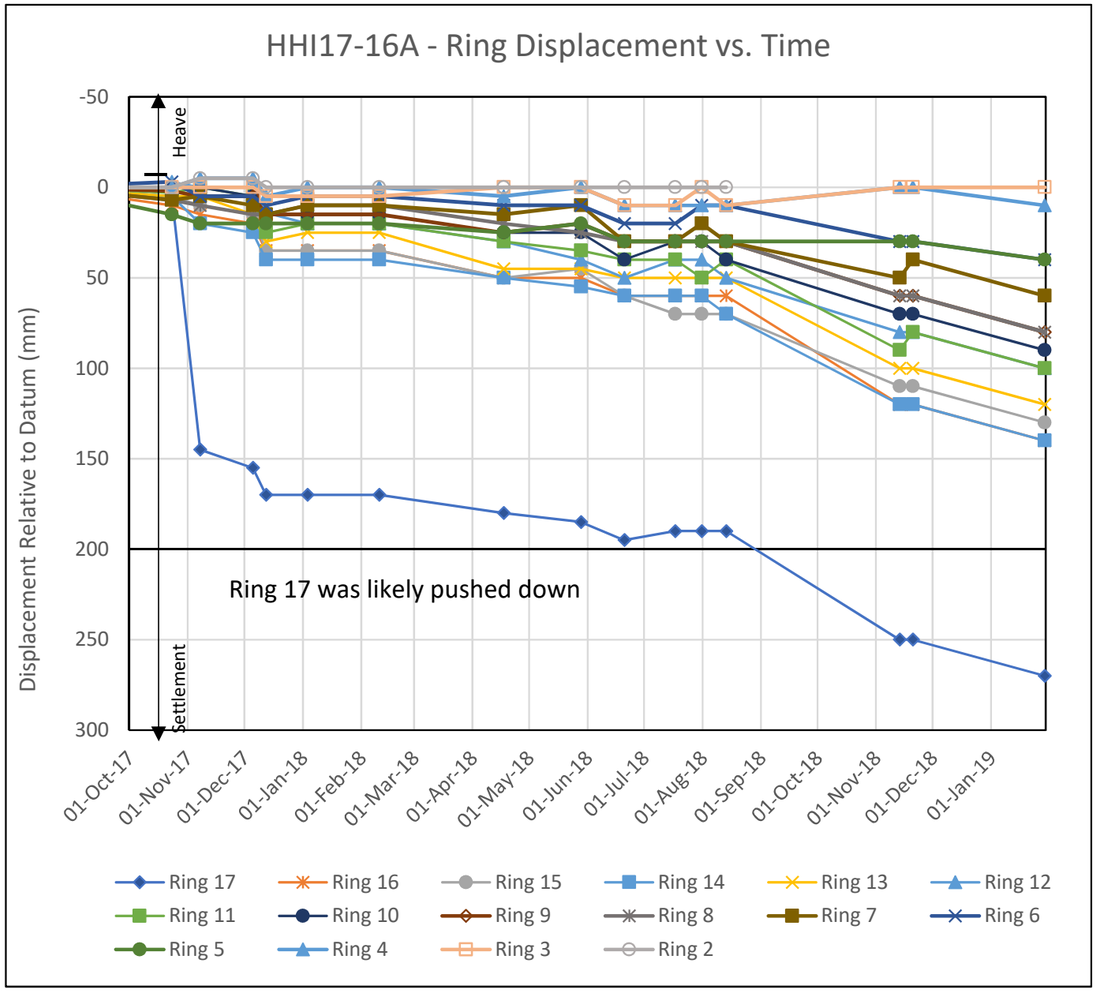
IV-38

FILE PATH: Z:\MV\VCR\M02341B53 - HVC 2019 DAM SAFETY SUPPORT\300 DESIGN\SONDEX DATA\190321 SONDEX READINGS WITH PLOTS (2018 DSI ONLY).XLSX - 2019-03-21 17:16









Notes:

1. Ring displacements are calculated relative to the initial elevations for each ring. The datum is the bottom ring (Ring 1).
2. Positive displacements represent settlement. Negative displacements represent heave.
3. The Ring 12 reading from December 11, 2017 was not consistent with readings in the rings above and below, due to a suspected data entry error. The reading was adjusted to match the trends of Ring 11 and Ring 13.
4. Data from October 09, and 30, 2018 were not consistent with other readings and not showed here.
5. No readings recorded for Ring 1 and 2 after October 09, 2018

Note: Baseline reading is February 25, 2018

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TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

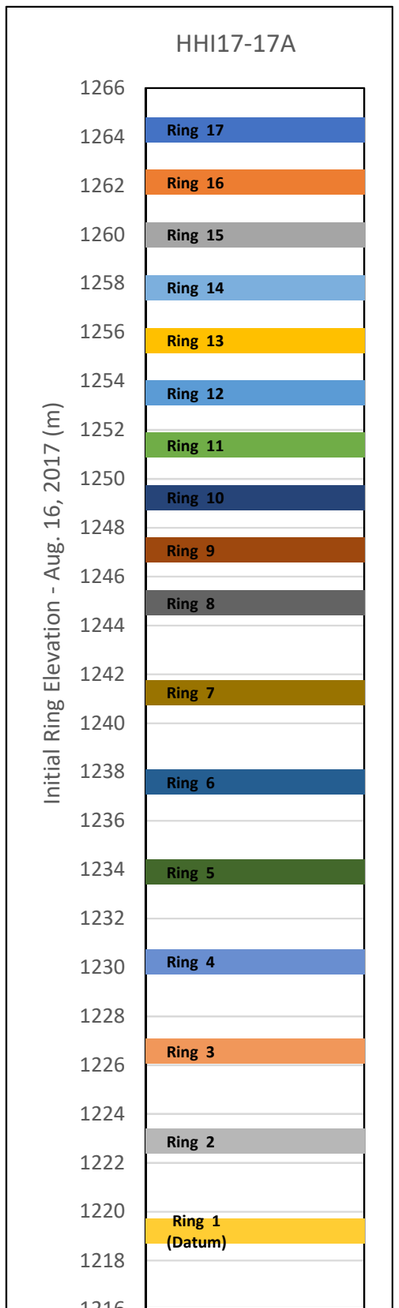
HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

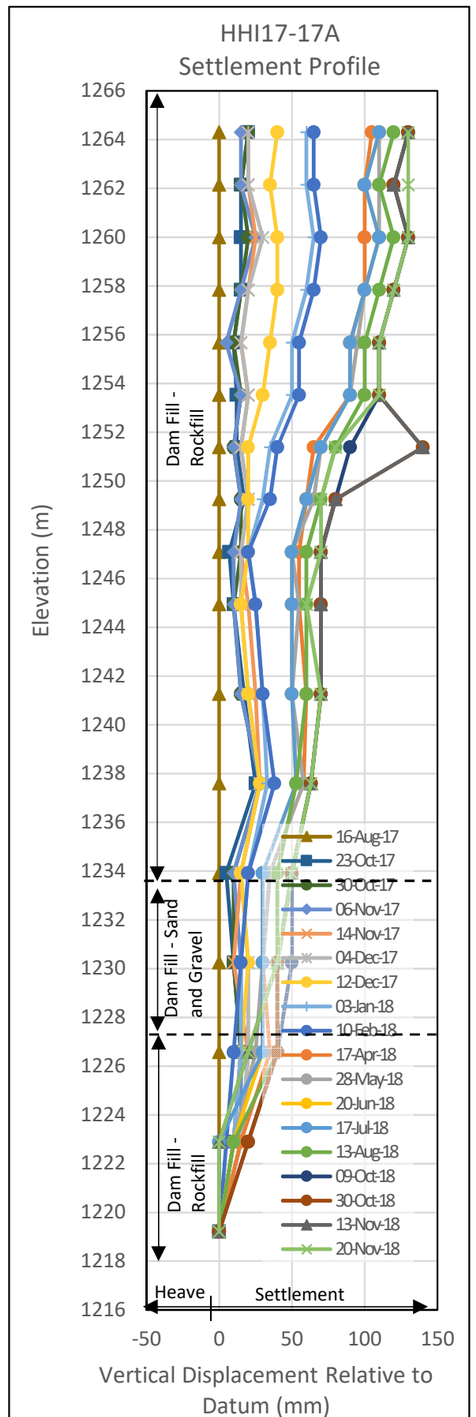
H-H Dam Vertical Displacements - HHI17-16A (Sondex)

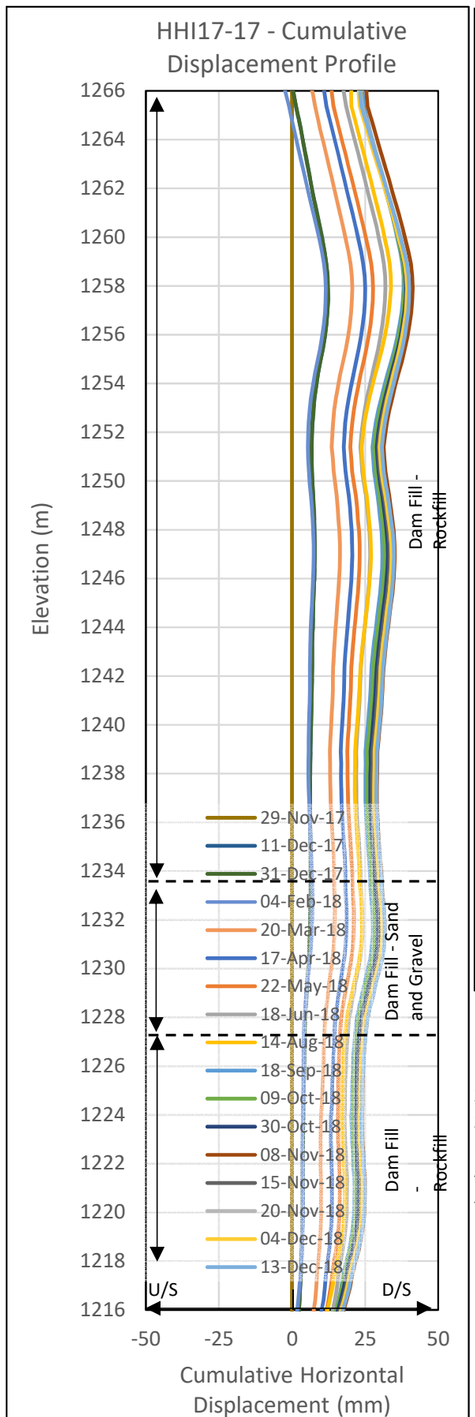
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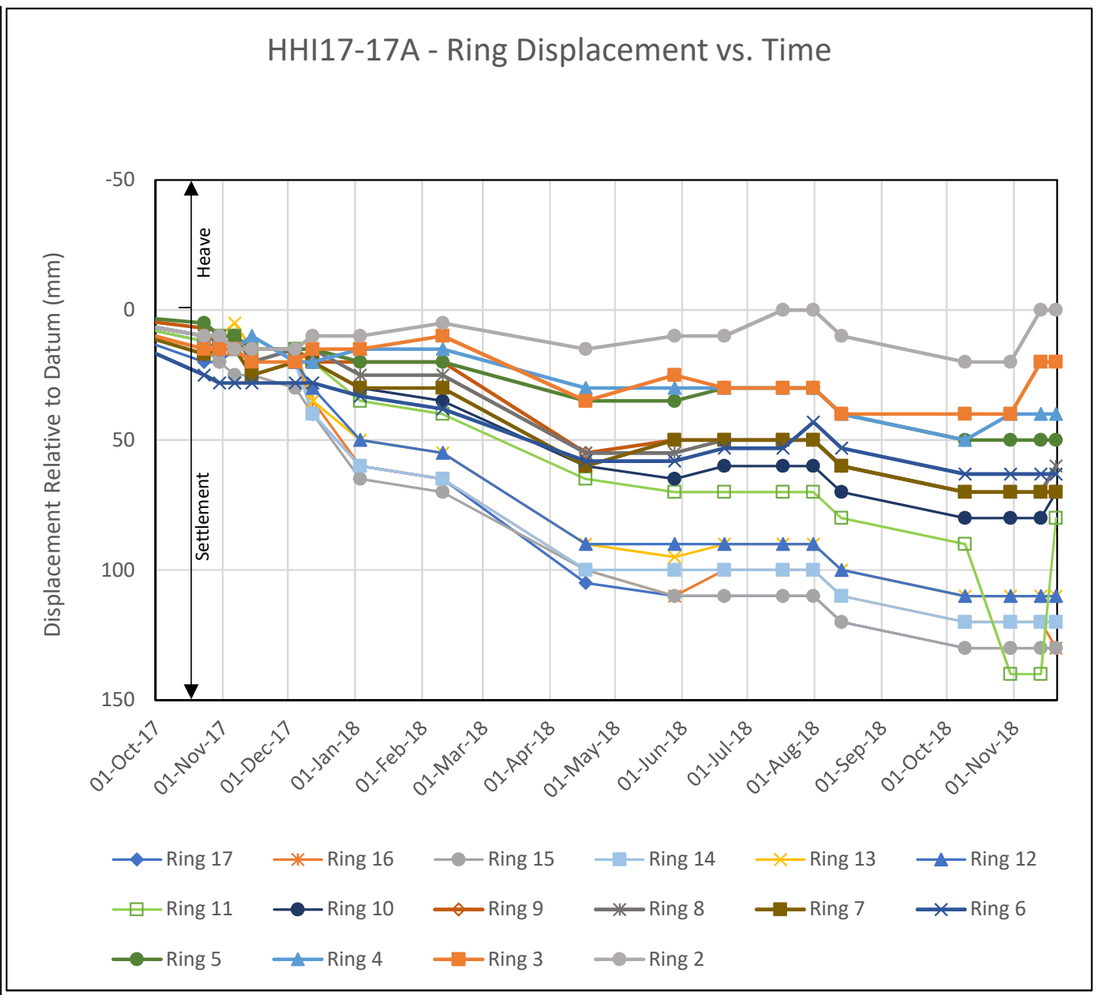
IV-39

FILE PATH: Z:\W\VCR\M02341B53 - HVC-2019 DAM SAFETY SUPPORT\300 DESIGN\SONDEX DATA\190321 SONDEX READINGS WITH PLOTS (2018 DSI ONLY).XLSX - 2019-03-21 17:16









Note: Baseline reading is November 29, 2017

Notes:
1. Ring displacements are calculated relative to the initial elevations for each ring. The datum is the bottom ring (Ring 1).
2. Positive displacements represent settlement. Negative displacements represent heave.
3. The following readings were not consistent with readings in the rings above and below, due to suspected data entry errors. The readings were adjusted to match the trends of adjacent rings:
-Ring 5 (December 11, 2017, January 3, 2018, February 10, 2018)
-Ring 6 (January 3, 2018)

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TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

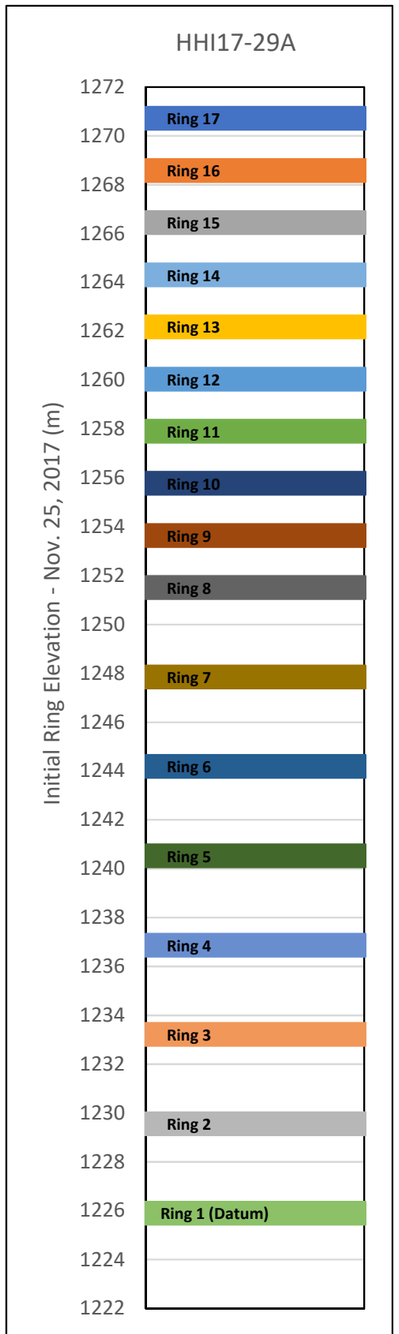
HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

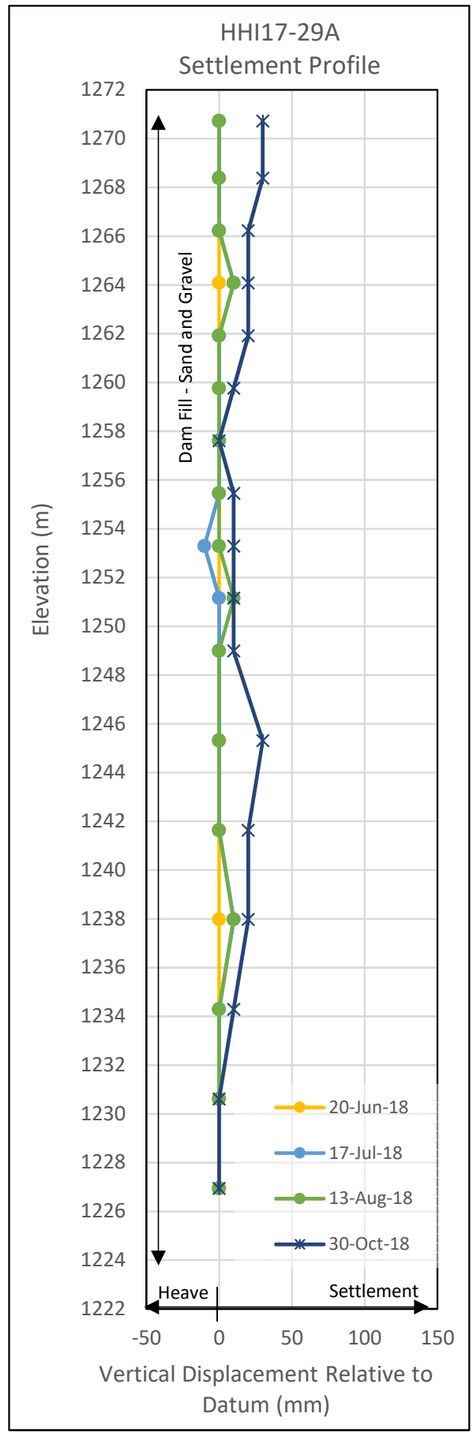
H-H Dam Vertical Displacements - HHI17-17A (Sondex)

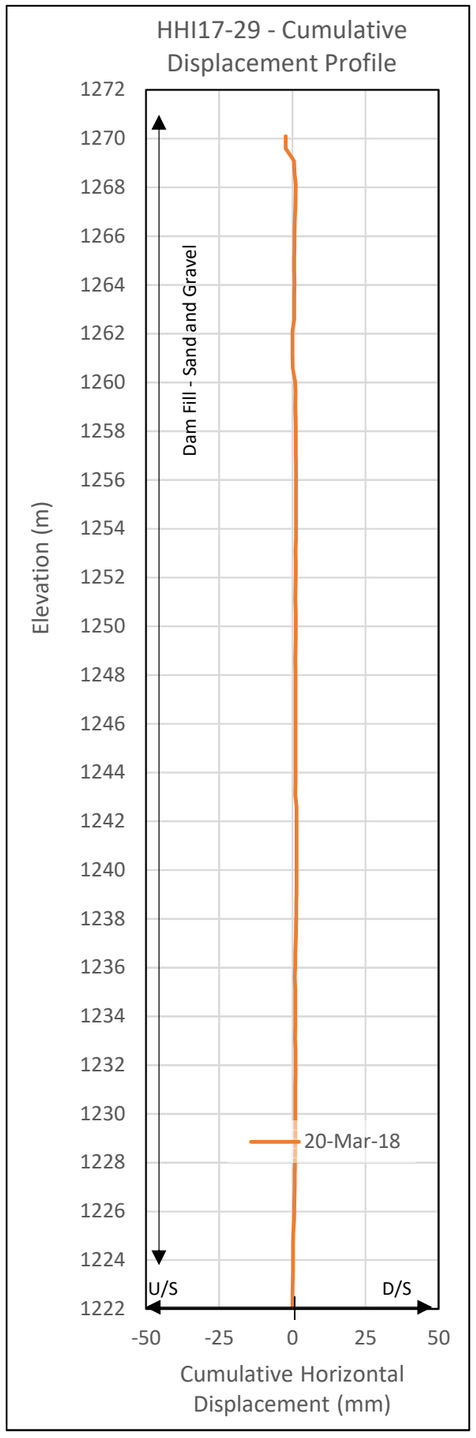
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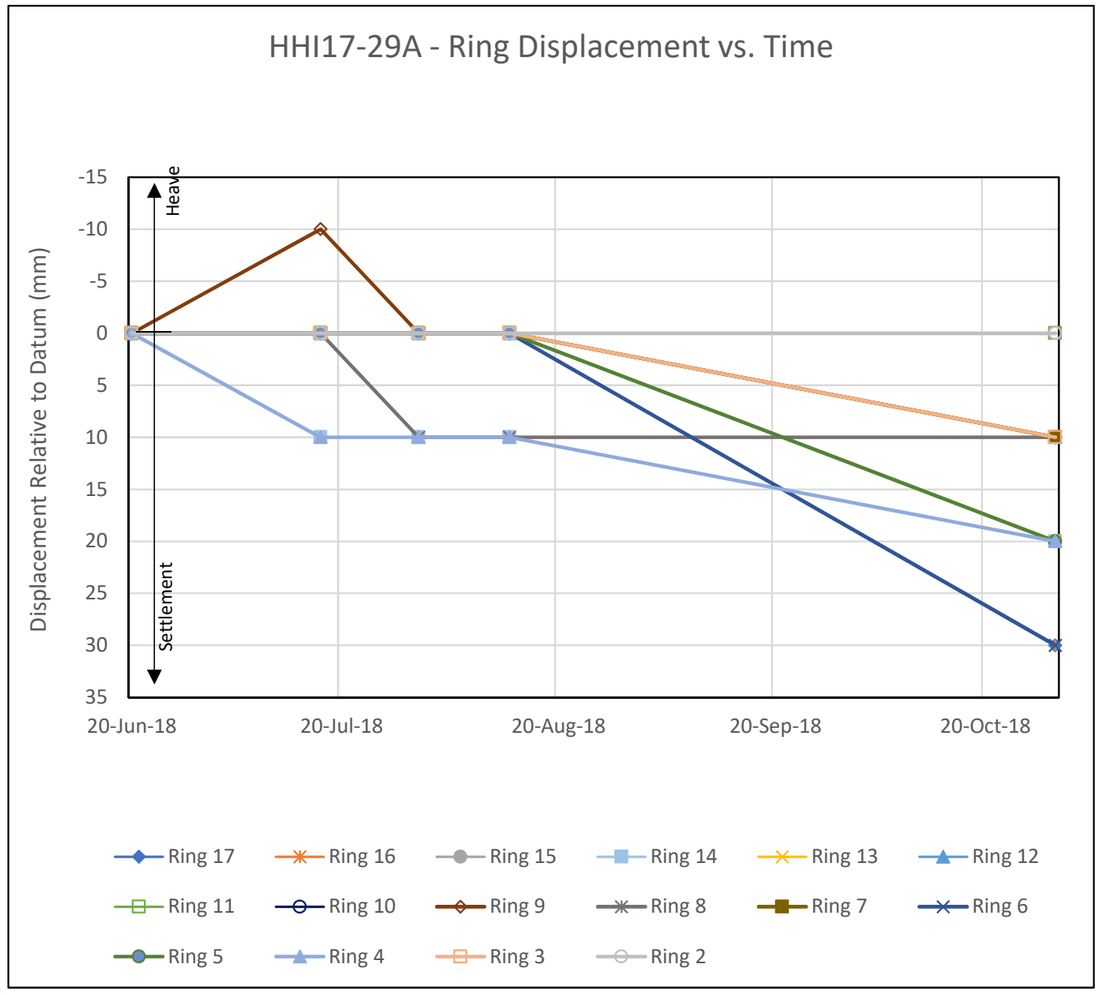
IV-40

FILE PATH: Z:\MV\VCR\M02341B53 - HVC-2019 DAM SAFETY SUPPORT\300 DESIGN\SONDEX DATA\190321 SONDEX READINGS WITH PLOTS (2018 DSI ONLY).XLSX - 2019-03-21 17:16









Notes:
1. Ring displacements are calculated relative to the initial elevations for each ring. The datum is the bottom ring (Ring 1).
2. Positive displacements represent settlement. Negative displacements represent heave.
3. The baseline reading of vertical displacemnet plot is Jun 20, 2018.

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TECK HIGHLAND VALLEY COPPER PARTNERSHIP

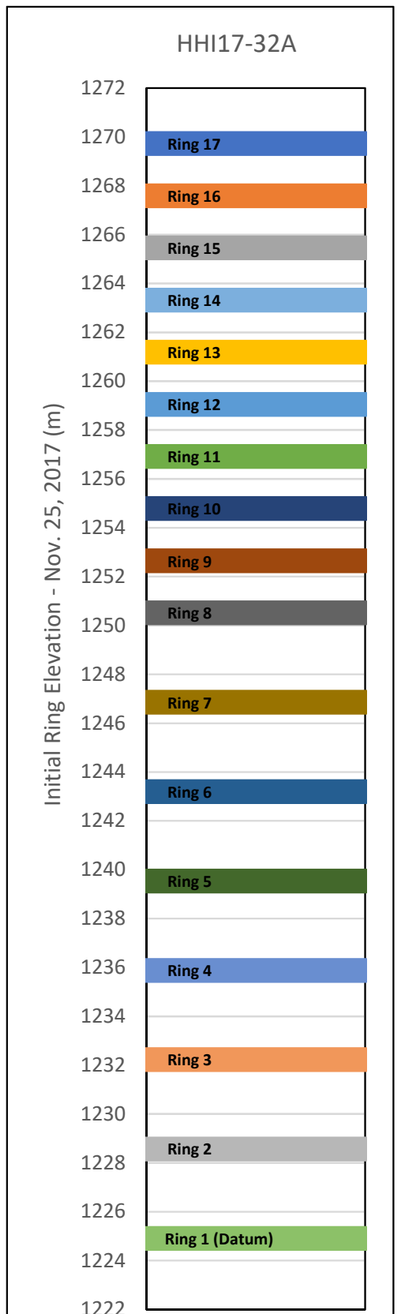
Klohn Crippen Berger

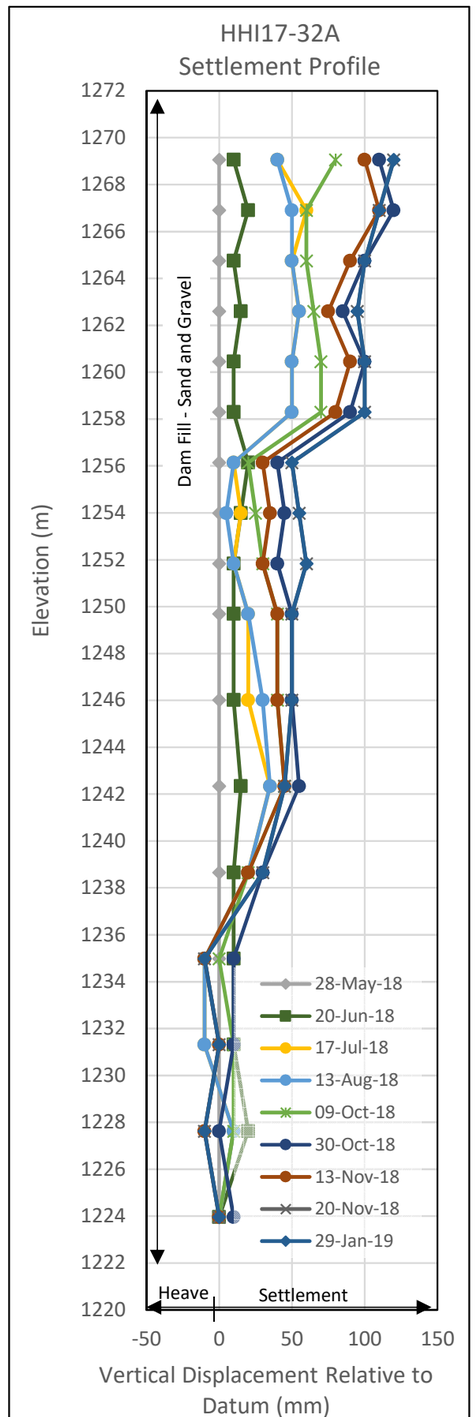
HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

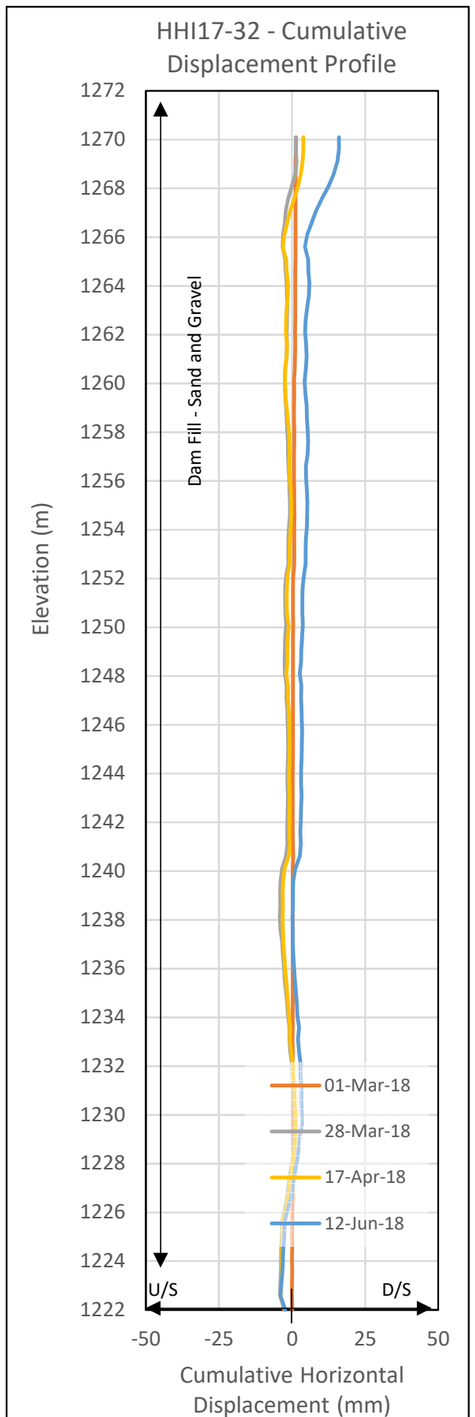
H-H Dam Vertical Displacements - HHI17-29A (Sondex)

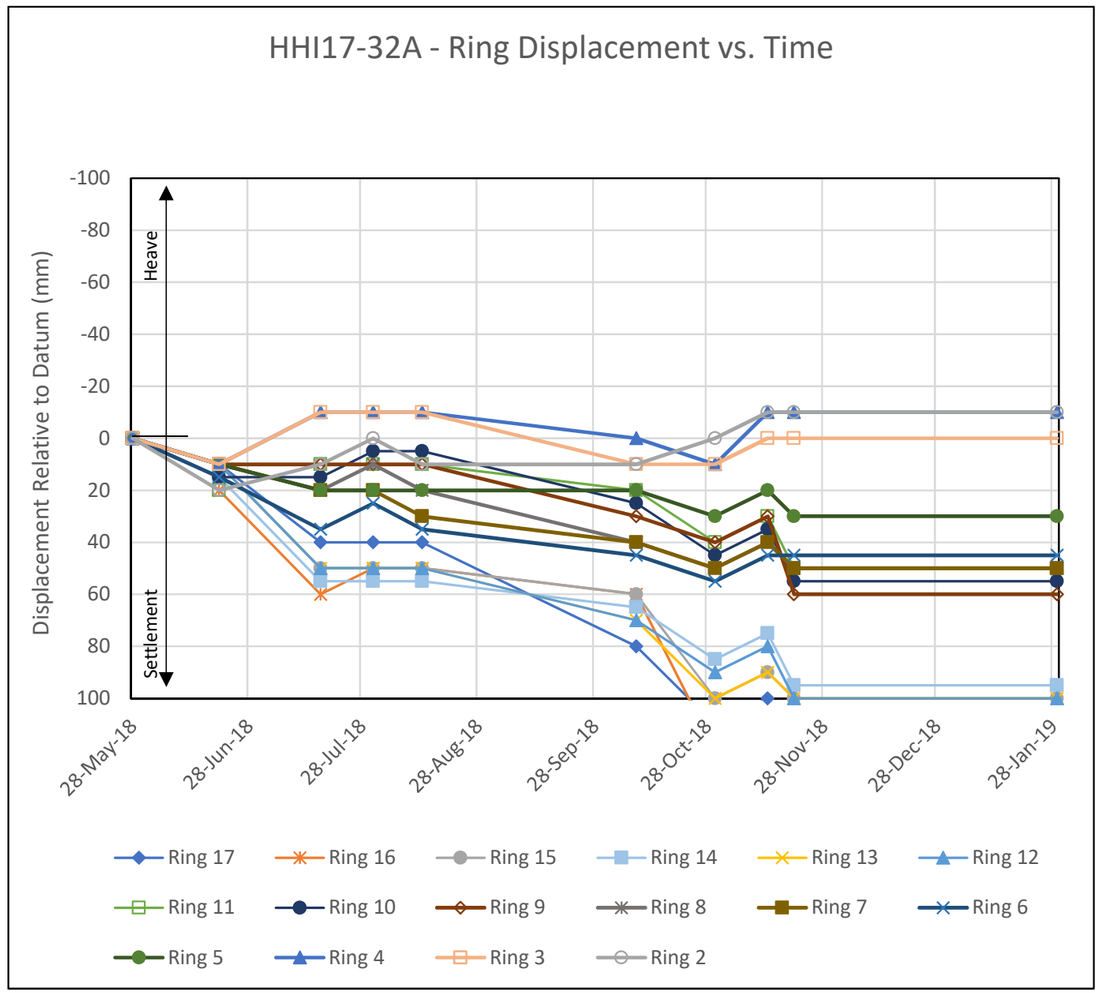
M02341B43 | IV-41

FILE PATH: Z:\MV\CR\M02341B53 - HVC-2019 DAM SAFETY SUPPORT\300 DESIGN\SONDEX DATA\190321 SONDEX READINGS WITH PLOTS (2018 DSI ONLY).XLSX - 2019-03-21 17:16









Notes:
1. Ring displacements are calculated relative to the initial elevations for each ring. The datum is the bottom ring (Ring 1).
2. Positive displacements represent settlement. Negative displacements represent heave.
3. Readings of October 30, and November 13, 2018 were not consistent and are adjusted.
3. The baseline reading of vertical displacemnet plot is May 28, 2018.

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TECK HIGHLAND VALLEY COPPER PARTNERSHIP

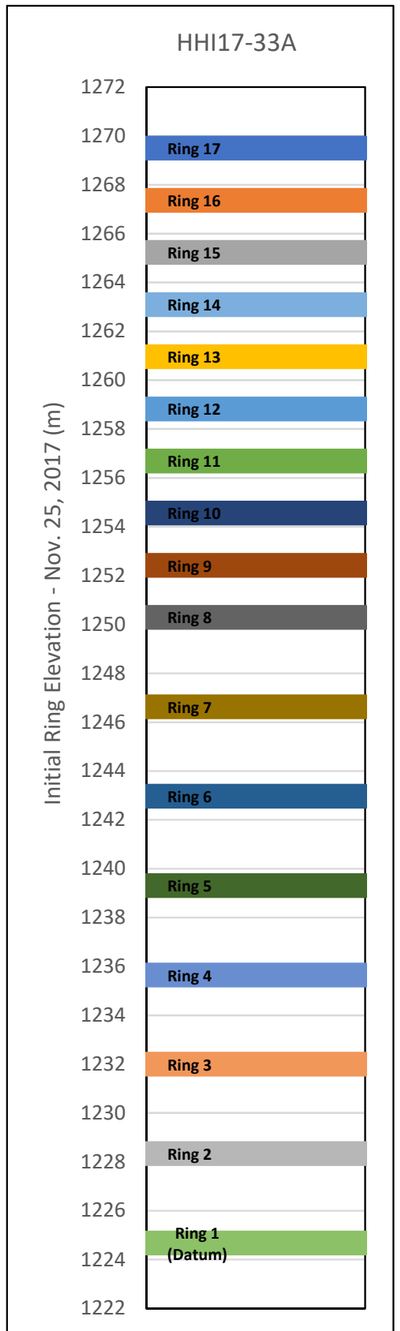
Klohn Crippen Berger

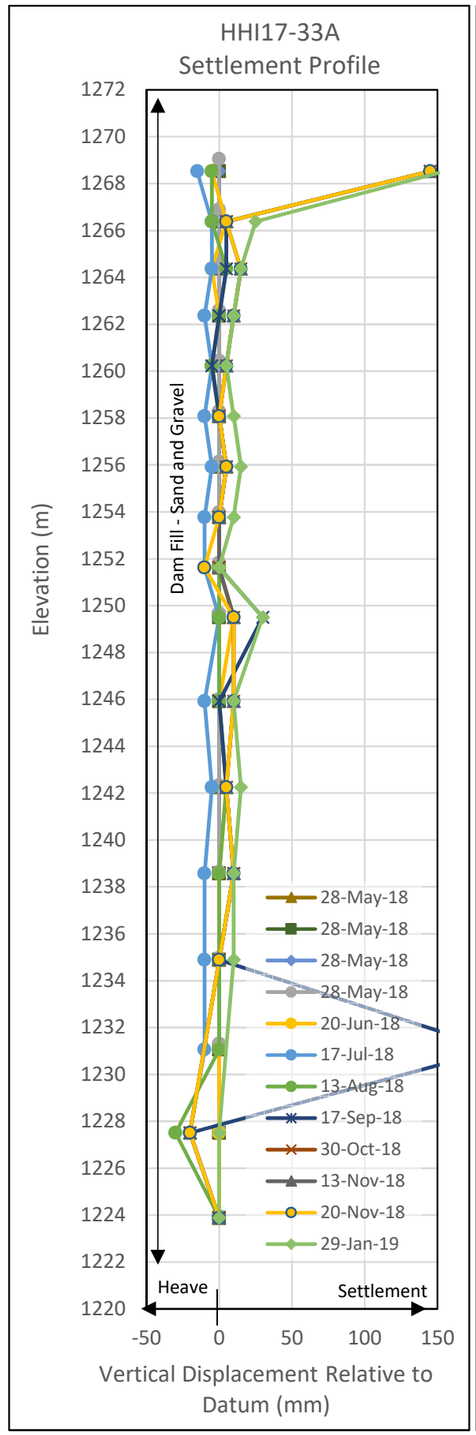
HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

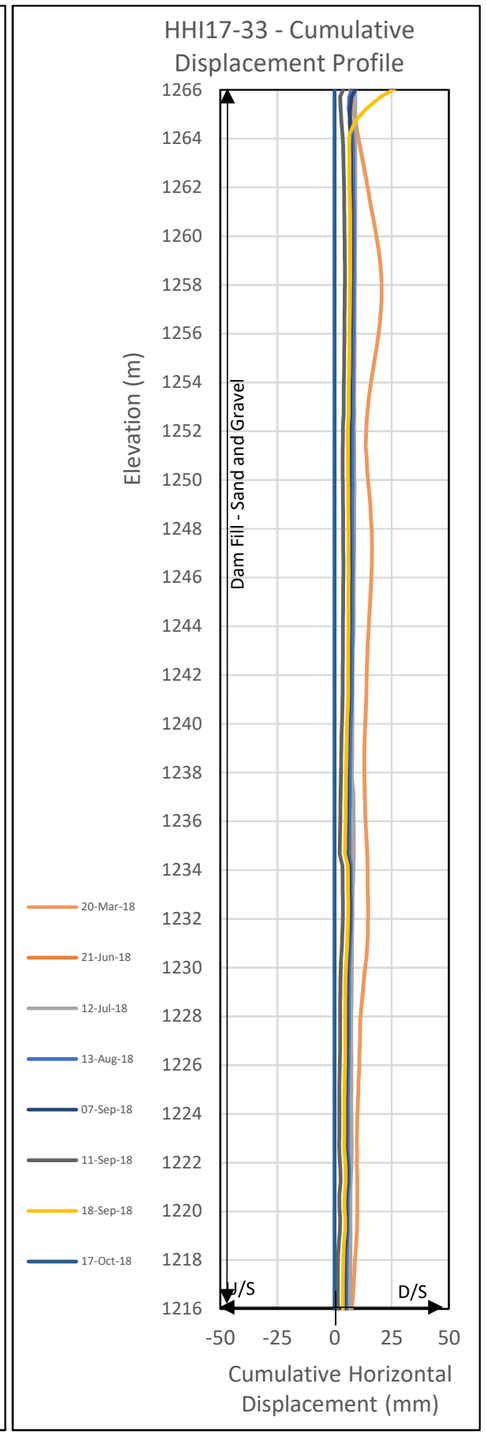
H-H Dam Vertical Displacements - HHI17-32A (Sondex)

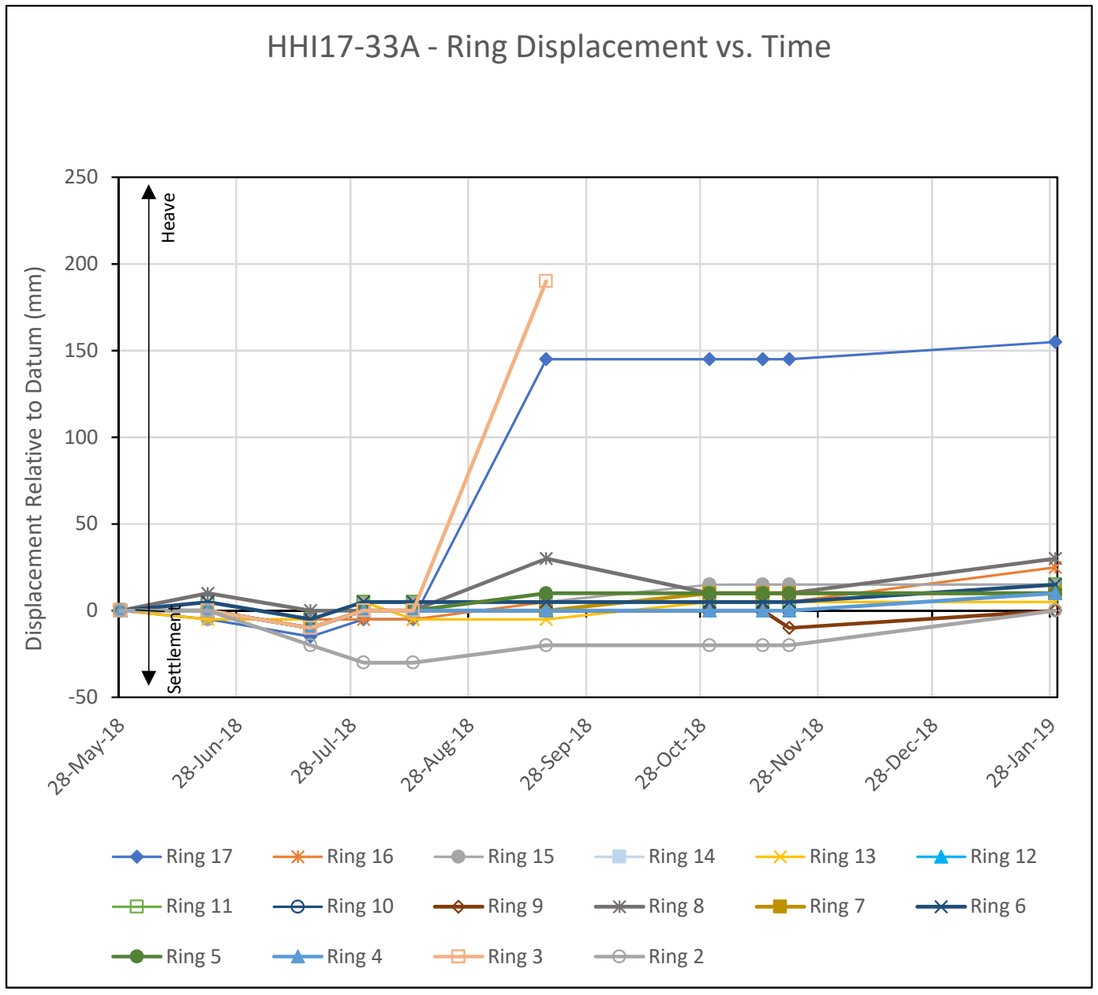
M02341B43 | IV-42

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Notes:
1. Ring displacements are calculated relative to the initial elevations for each ring. The datum is the bottom ring (Ring 1).
2. Positive displacements represent settlement. Negative displacements represent heave.

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TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

H-H Dam Vertical Displacements - HHI17-33A (Sondex)

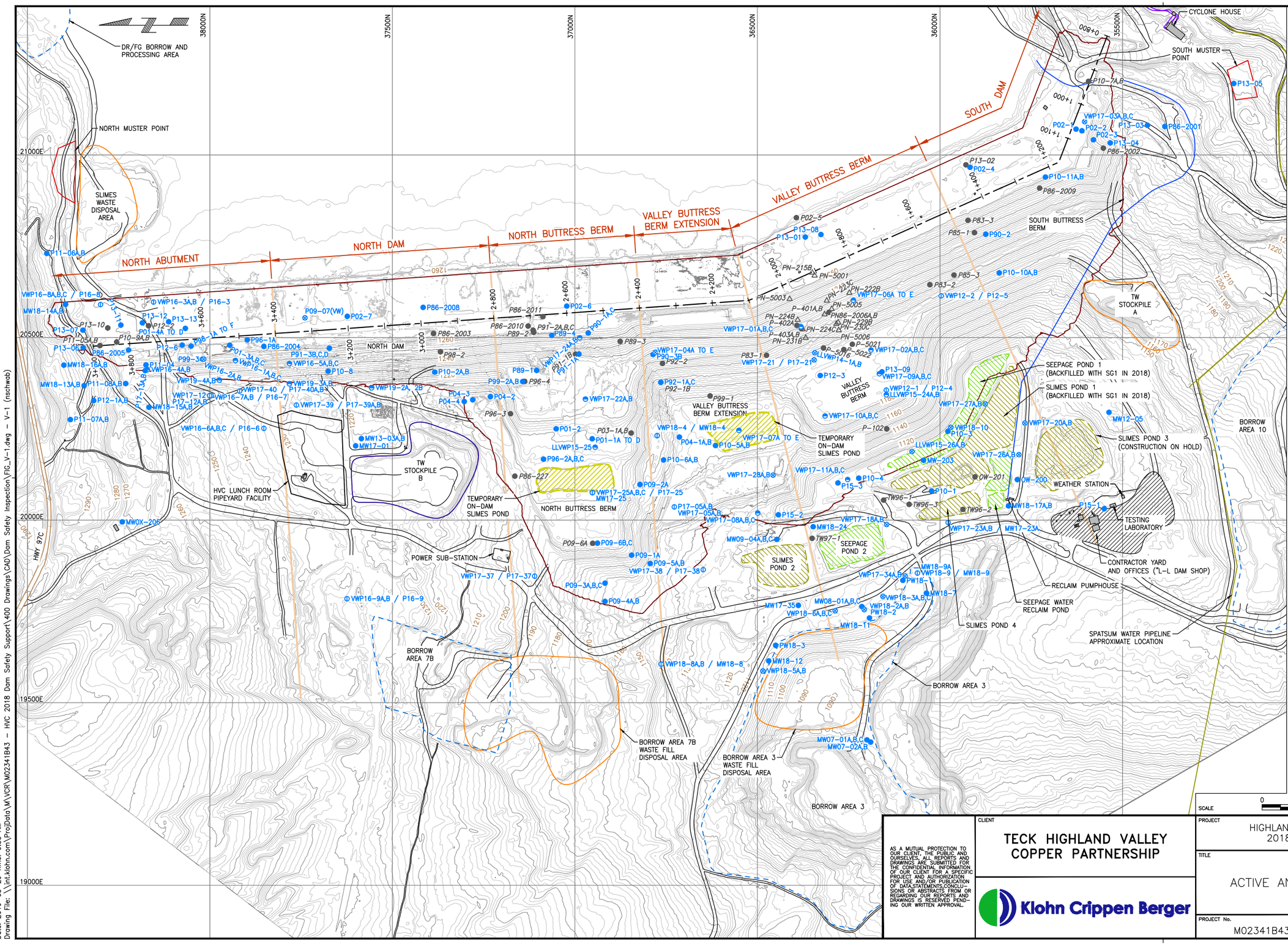
M02341B43 | IV-43

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APPENDIX V

Piezometer Plots

L-L DAM ACTIVE AND DEFUNCT PIEZOMETERS LOCATION PLAN



LEGEND:

- BORROW AREA
- WASTE FILL DISPOSAL AREA
- SEEPAGE POND
- SLIMES POND
- EL. 1279 m ULTIMATE DAM FOOTPRINT
- SURFACE WATER RECLAIM PIPELINE
- SPATSUM WATER PIPELINE
- HAUL ROAD
- PUBLIC ROAD
- L-L DAM CENTERLINE (0+800)

ACTIVE INSTRUMENTS (SEE NOTE 2):

- STANDPIPE PIEZOMETER AND OBSERVATION WELL
- VIBRATING-WIRE PIEZOMETER
- COMBINED STANDPIPE PIEZOMETER AND VIBRATING-WIRE PIEZOMETER
- COMBINED INCLINOMETER AND VIBRATING-WIRE PIEZOMETER

DEFUNCT INSTRUMENTS (SEE NOTE 3):

- DEFUNCT PNEUMATIC PIEZOMETER
- DEFUNCT STANDPIPE PIEZOMETER

NOTES:

1. TOPOGRAPHY OF L-L DAM IS GENERALLY BASED ON THE FOLLOWING:
   - AREAS OUTSIDE THE DAM FOOTPRINT ARE BASED ON OCTOBER 2018 PHOTOSAT SURVEY.
   - AREAS OF HYDRAULICALLY PLACED FILLS ARE BASED ON AS-BUILT SURVEYS PROVIDED BY TECK HIGHLAND VALLEY COPPER DATED 2018-12-10 (II-HS-3), 2018-11-14 (I-HS-1), 2018-10-22 (I-HS-2), 2018-12-05 (VBBE) AND 2018-12-17 (I-HS-4).
   - AREAS OF MECHANICALLY PLACED FILLS (SG1, S1 AND S2) AND FOUNDATION EXCAVATIONS (I-E-1, I-E-2, I-A-1, I-A-2, II-E-1, II-E-2, II-E-3) ARE GENERALLY BASED ON AS-BUILT SURVEYS PROVIDED BY NORTH AMERICAN CONSTRUCTION GROUP, DATED 2019-02-06 (COMPILED L-L APPROVED FOUNDATIONS), 2019-02-14 (COMPILED L-L S1 BLANKET), AND 2019-02-13 (COMPILED SG1 BLANKET).
2. ACTIVE INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: CURRENTLY READING AN ACTIVE WATER LEVEL, DRY OR PLUGGED <20 m ABOVE TIP ELEVATION AS THIS COULD SHOW A RESPONSE IN THE FUTURE.
3. DEFUNCT INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: DESTROYED, DAMAGED OR PLUGGED >20 m ABOVE TIP ELEVATION.

SCALE 0 250 m

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

TITLE
L-L DAM
ACTIVE AND DEFUNCT PIEZOMETERS
LOCATION PLAN

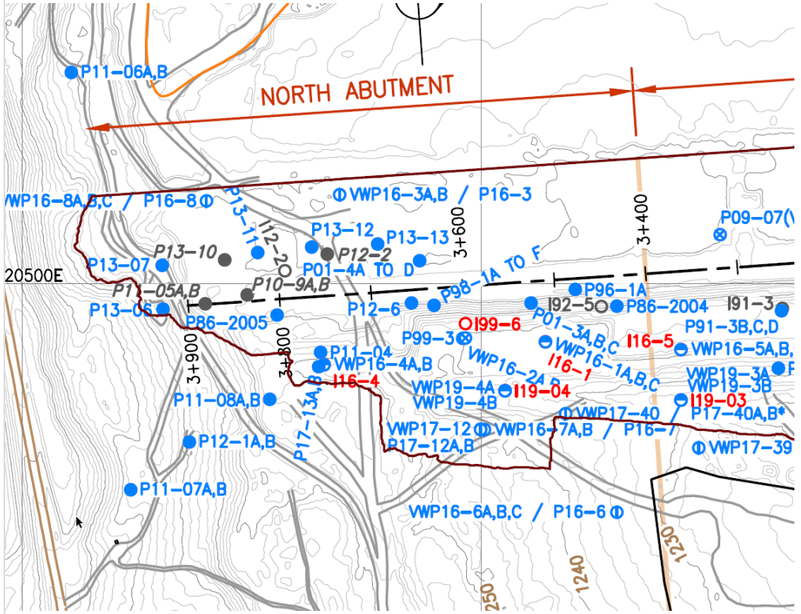
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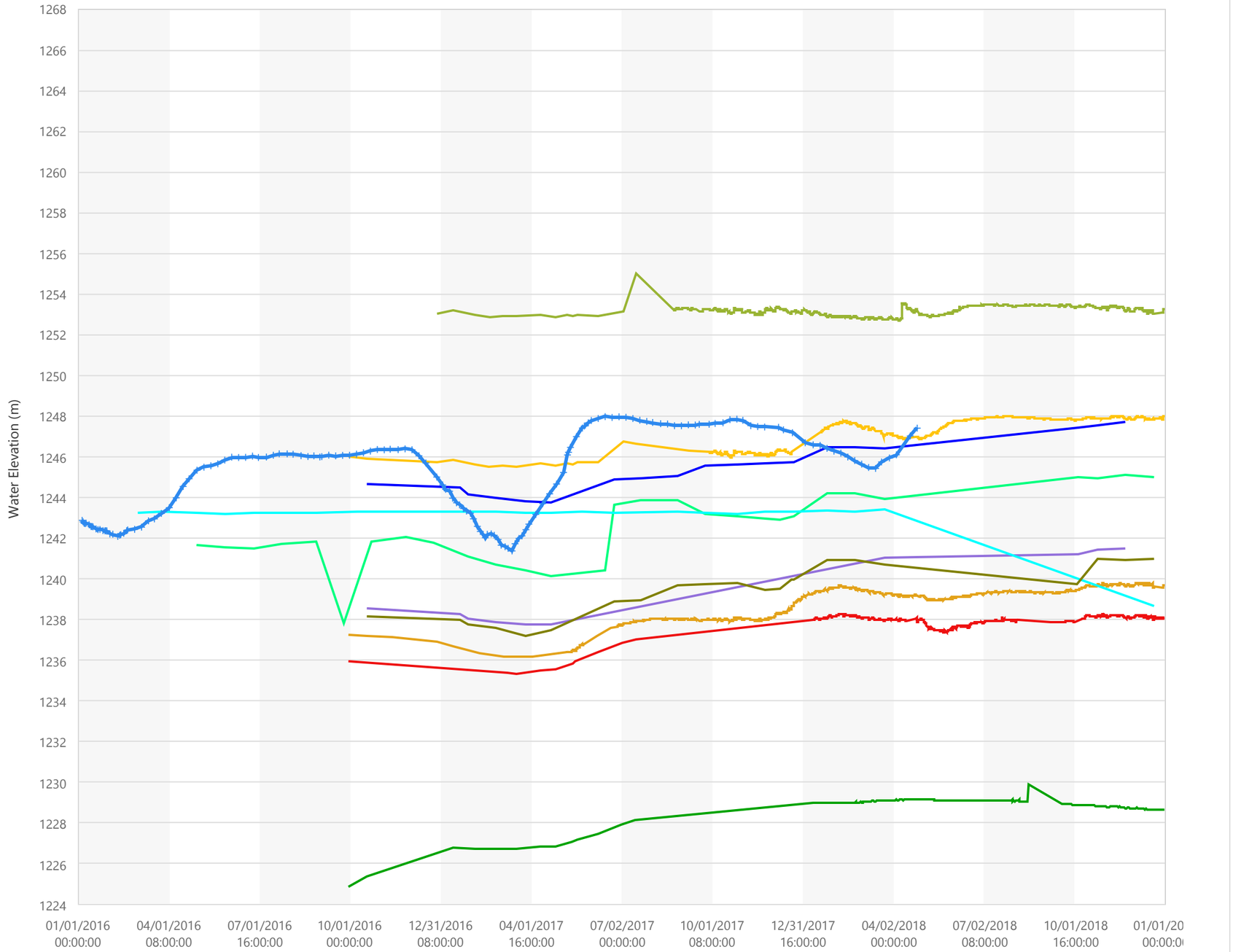
FIG. No. V-1

KCB-R-MLD

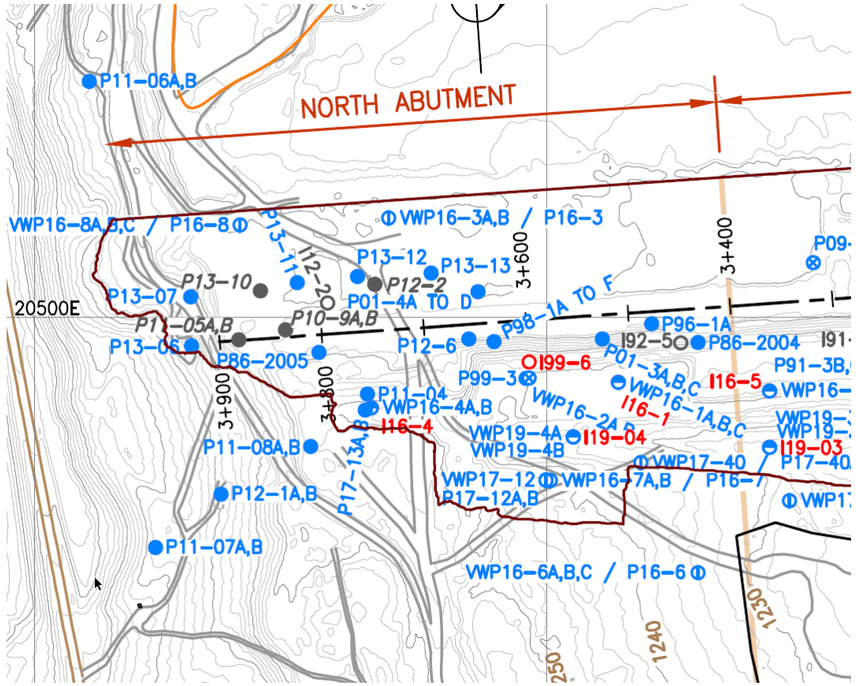
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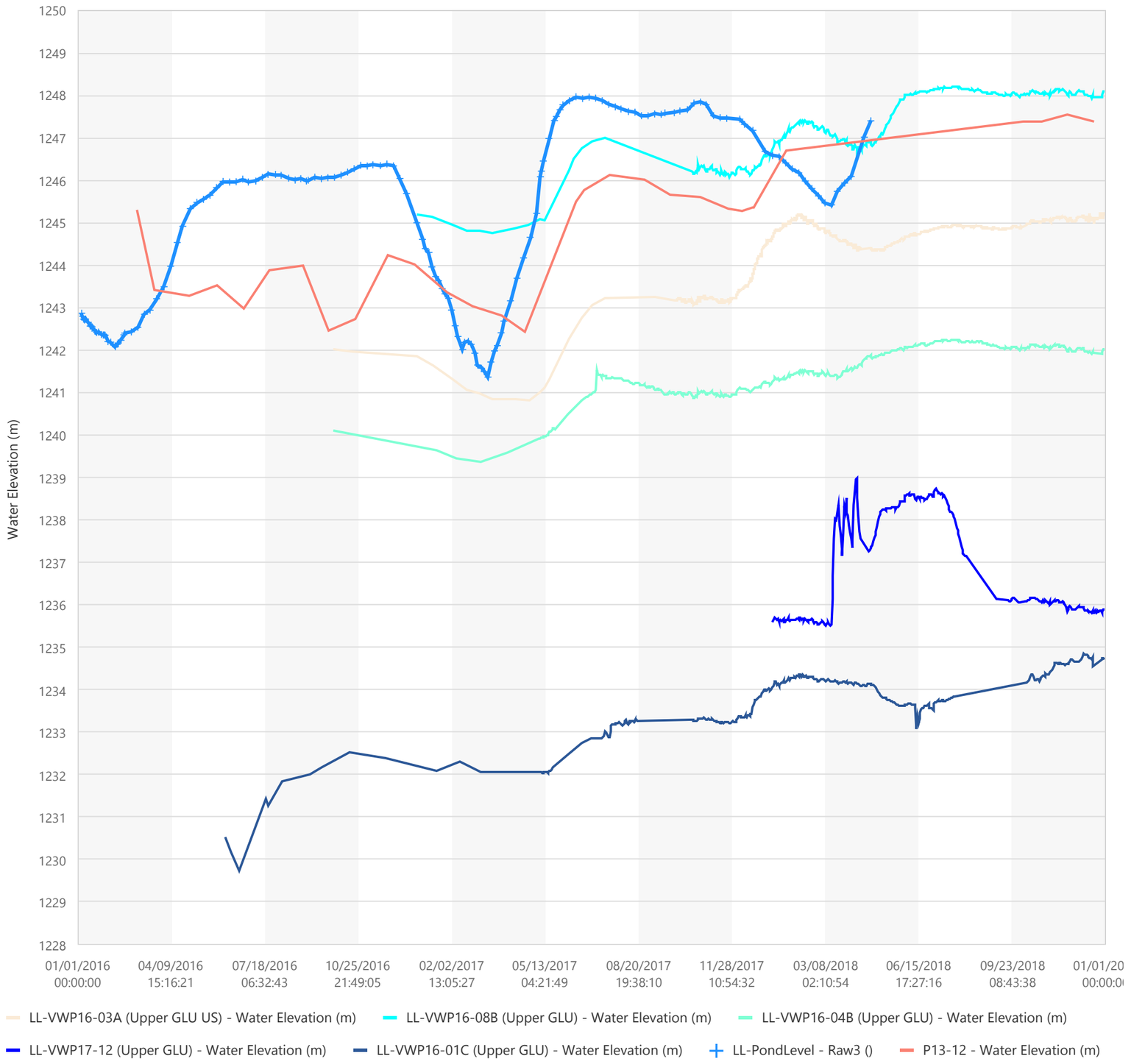
NORTH ABUTMENT - SAND AND GRAVEL


NORTH ABUTMENT
20500E
P11-06A,B
VWP16-8A,B,C / P16-8
VWP16-3A,B / P16-3
P13-12
P13-13
P13-10
P12-2
P13-07
P01-4A TO D
P10-9A,B
P11-05A,B
P13-06
P12-6
P98-1A TO F
P96-1A
I92-5
P86-2004
I91-3
P86-2005
I99-6
P99-3
P01-3A,B,C
I16-5
P91-3B,C,D
VWP16-5A,B,
P11-04
VWP16-4A,B
VWP16-24 B
I16-1
VWP16-1A,B,C
VWP19-3A
VWP19-3B
P11-08A,B
I16-4
VWP19-4A
I19-04
VWP19-4B
I19-03
P17-13A,B
VWP17-40
P17-40A,B
VWP17-12
VWP16-7A,B / P16-7
P17-12A,B
VWP17-39
P12-1A,B
P11-07A,B
VWP16-6A,B,C / P16-6
3+900
3+800
3+600
3+400
1250
1240
1230

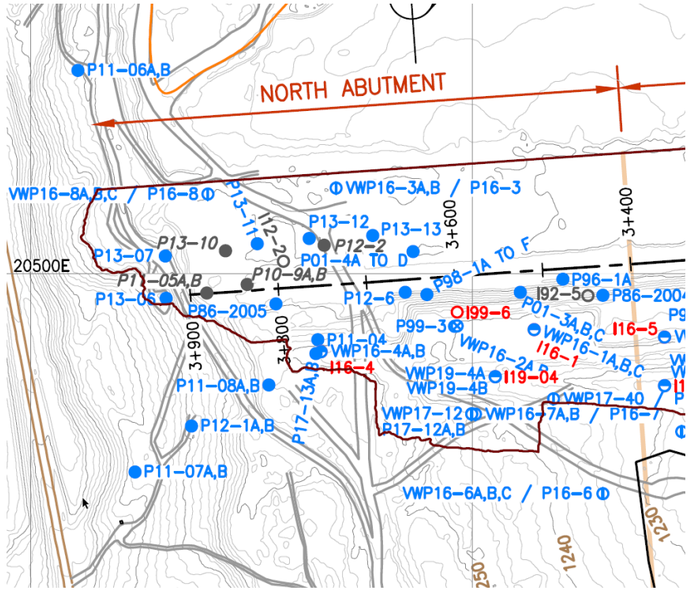

Water Elevation (m)
1268
1266
1264
1262
1260
1258
1256
1254
1252
1250
1248
1246
1244
1242
1240
1238
1236
1234
1232
1230
1228
1226
1224
01/01/2016 00:00:00
04/01/2016 08:00:00
07/01/2016 16:00:00
10/01/2016 00:00:00
12/31/2016 08:00:00
04/01/2017 16:00:00
07/02/2017 00:00:00
10/01/2017 08:00:00
12/31/2017 16:00:00
04/02/2018 00:00:00
07/02/2018 08:00:00
10/01/2018 16:00:00
01/01/20 00:00:0
LL-VWP16-04A (Sand and Gravel Lower) - Water Elevation (m)
LL-VWP16-06C (Sand and Gravel Upper) - Water Elevation (m)
LL-VWP16-07B (Lower S&G) - Water Elevation (m)
LL-VWP16-03B (Sand and Gravel Upper) - Water Elevation (m)
LL-VWP16-08C (Sand and Gravel Upper) - Water Elevation (m)
P10-09B - Water Elevation (m)
P13-11 - Water Elevation (m)
P16-03 - Water Elevation (m)
P16-08 - Water Elevation (m)
P86-2005 - Water Elevation (m)
P16-07 - Water Elevation (m)
P17-13A - Water Elevation (m)
LL-PondLevel - Raw3 ()

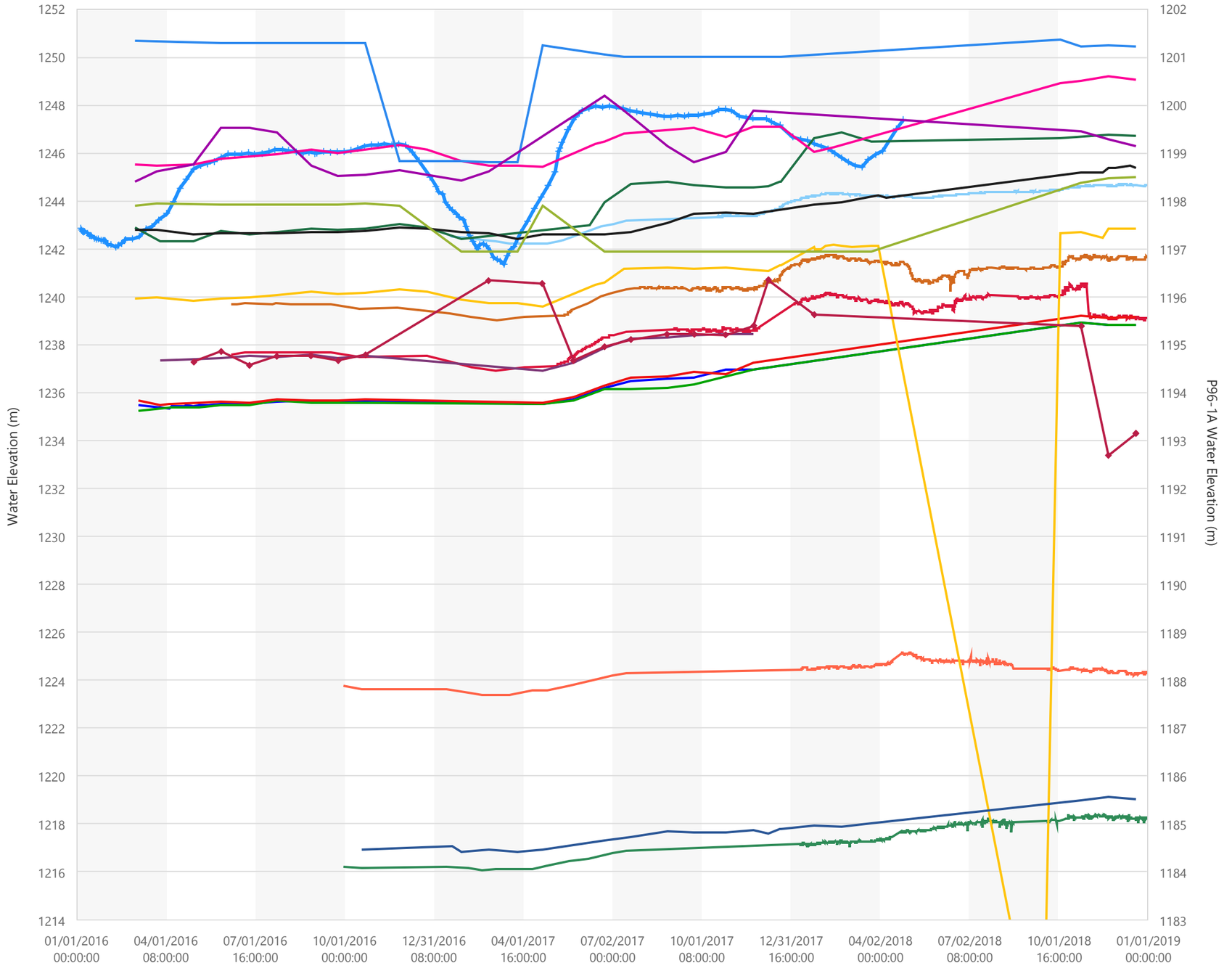
NORTH ABUTMENT - GLACIOLACUSTRINE


NORTH ABUTMENT
20500E
P11–06A,B
VWP16–8A,B,C / P16–8
VWP16–3A,B / P16–3
P13–10
P13–07
P13–05A,B
P13–06
P13–12
P13–13
P12–2
P01–4A TO D
P10–9A,B
P98–1A TO F
P12–6
P86–2005
P96–1A
P86–2004
I92–5
I99–6
P99–3
P01–3A,B,C
I16–5
VWP16–1A,B,C
I16–1
VWP16–2A,B
P11–04
VWP16–4A,B
I16–4
VWP19–4A
I19–04
VWP19–4B
I19–03
P11–08A,B
P12–1A,B
P17–13A,B
VWP17–12
VWP16–7A,B / P16–7
P17–12A,B
VWP17–40 / P17–40
P11–07A,B
VWP16–6A,B,C / P16–6
3+900
3+800
3+600
3+400
1250
1240
1230

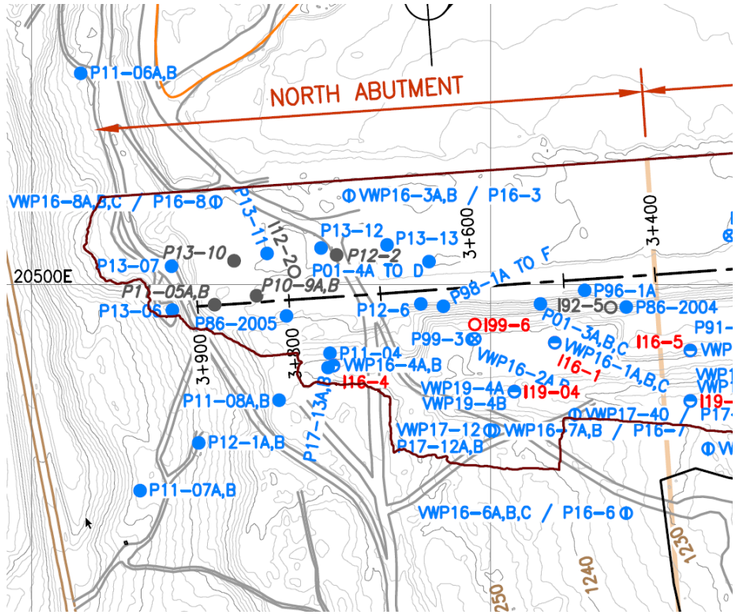

Water Elevation (m)
1250
1249
1248
1247
1246
1245
1244
1243
1242
1241
1240
1239
1238
1237
1236
1235
1234
1233
1232
1231
1230
1229
1228
01/01/2016 00:00:00
04/09/2016 15:16:21
07/18/2016 06:32:43
10/25/2016 21:49:05
02/02/2017 13:05:27
05/13/2017 04:21:49
08/20/2017 19:38:10
11/28/2017 10:54:32
03/08/2018 02:10:54
06/15/2018 17:27:16
09/23/2018 08:43:38
LL-VWP16-03A (Upper GLU US) - Water Elevation (m)
LL-VWP16-08B (Upper GLU) - Water Elevation (m)
LL-VWP16-04B (Upper GLU) - Water Elevation (m)
LL-VWP17-12 (Upper GLU) - Water Elevation (m)
LL-VWP16-01C (Upper GLU) - Water Elevation (m)
LL-PondLevel - Raw3 ()
P13-12 - Water Elevation (m)

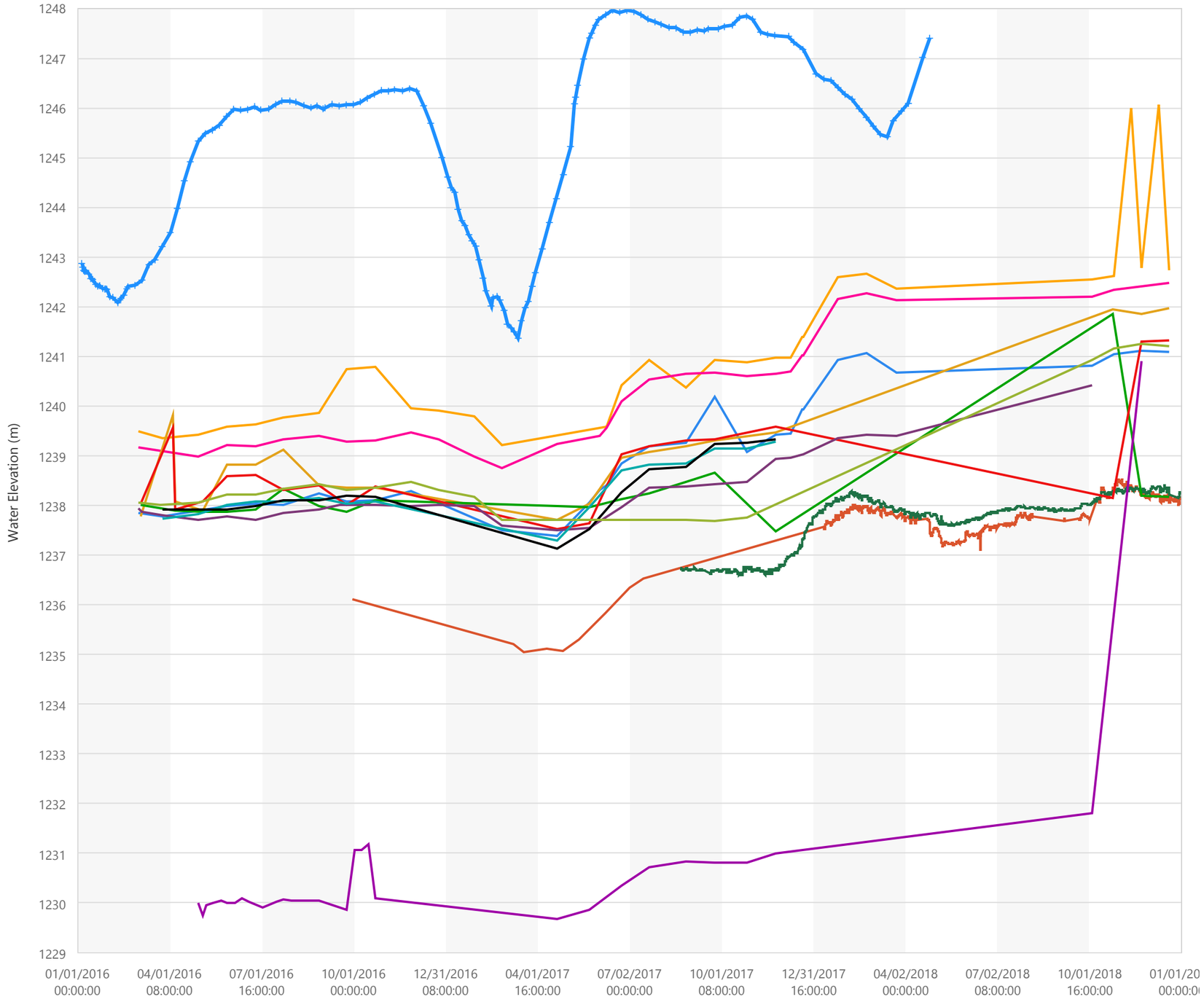
NORTH ABUTMENT - GLACIAL TILL


NORTH ABUTMENT
20500E
P11-06A,B
VWP16-8A,B,C / P16-8
VWP16-3A,B / P16-3
P13-10
P13-07
P11-05A,B
P13-06
P10-9A,B
P86-2005
P13-12
P13-13
P12-2
P01-4A TO D
P98-1A TO F
P12-6
P99-3
I99-6
P11-04
VWP16-4A,B
I16-4
P11-08A,B
P12-1A,B
P11-07A,B
P17-13A,B
P17-12A,B
VWP17-12
VWP16-7A,B / P16-7
VWP19-4A
VWP19-4B
I19-04
VWP16-2A,B
VWP16-1A,B,C
P01-3A,B,C
I16-5
I16-1
I92-5
P96-1A
P86-200
VWP17-40
VWP16-6A,B,C / P16-6
3+600
3+400
3+900
3+800
1250
1240
1230

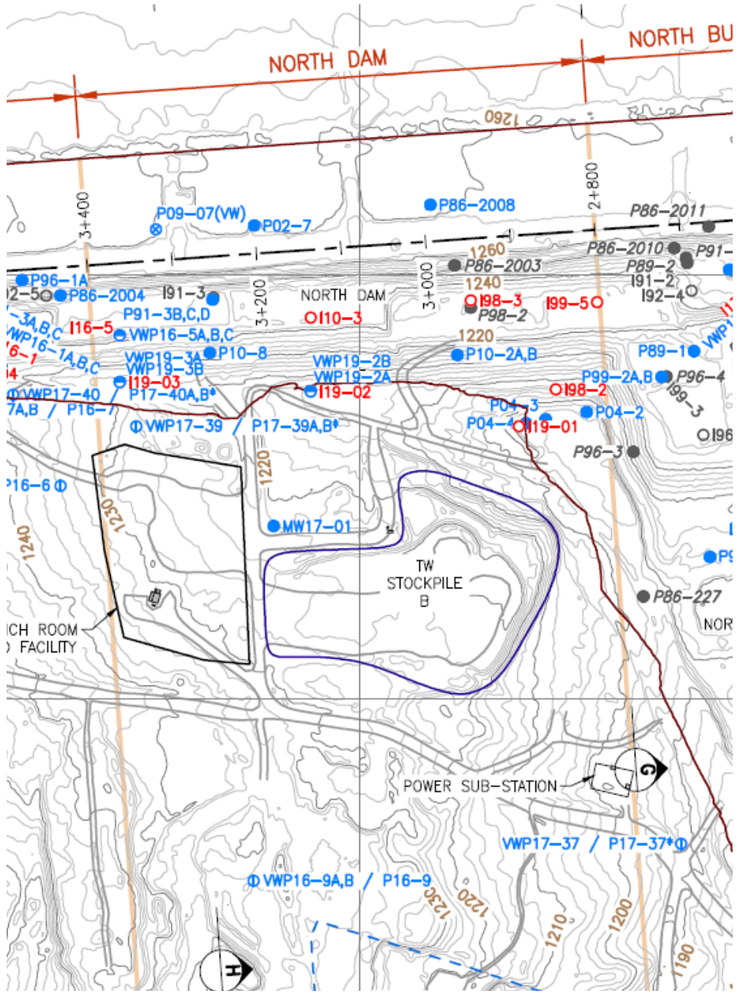

Water Elevation (m)
P96-1A Water Elevation (m)
1252
1250
1248
1246
1244
1242
1240
1238
1236
1234
1232
1230
1228
1226
1224
1222
1220
1218
1216
1214
1202
1201
1200
1199
1198
1197
1196
1195
1194
1193
1192
1191
1190
1189
1188
1187
1186
1185
1184
1183
01/01/2016 00:00:00
04/01/2016 08:00:00
07/01/2016 16:00:00
10/01/2016 00:00:00
12/31/2016 08:00:00
04/01/2017 16:00:00
07/02/2017 00:00:00
10/01/2017 08:00:00
12/31/2017 16:00:00
04/02/2018 00:00:00
07/02/2018 08:00:00
10/01/2018 16:00:00
01/01/2019 00:00:00
LL-VWP16-08A (Glacial Till Stratisfied) - Water Elevation (m)
LL-VWP16-01B (Glacial Till) - Water Elevation (m)
LL-VWP16-02A (Glacial Till Stratisfied) - Water Elevation (m)
LL-VWP16-06A (Glacial Till Stratisfied) - Water Elevation (m)
LL-VWP16-06B (Glacial Till Stratisfied) - Water Elevation (m)
LL-PondLevel - Raw3 ()
P01-4A - Water Elevation (m)
P13-7 - Water Elevation (m)
P13-10 - Water Elevation (m)
P11-6A - Water Elevation (m)
P11-6B - Water Elevation (m)
P98-1A - Water Elevation (m)
P98-1B - Water Elevation (m)
P98-1C - Water Elevation (m)
P01-3A - Water Elevation (m)
P10-09A - Water Elevation (m)
P11-4 - Water Elevation (m)
P13-6 - Water Elevation (m)
P96-1A - Water Elevation (m)
P11-8B - Water Elevation (m)
P16-06 - Water Elevation (m)
P17-12A - Water Elevation (m)

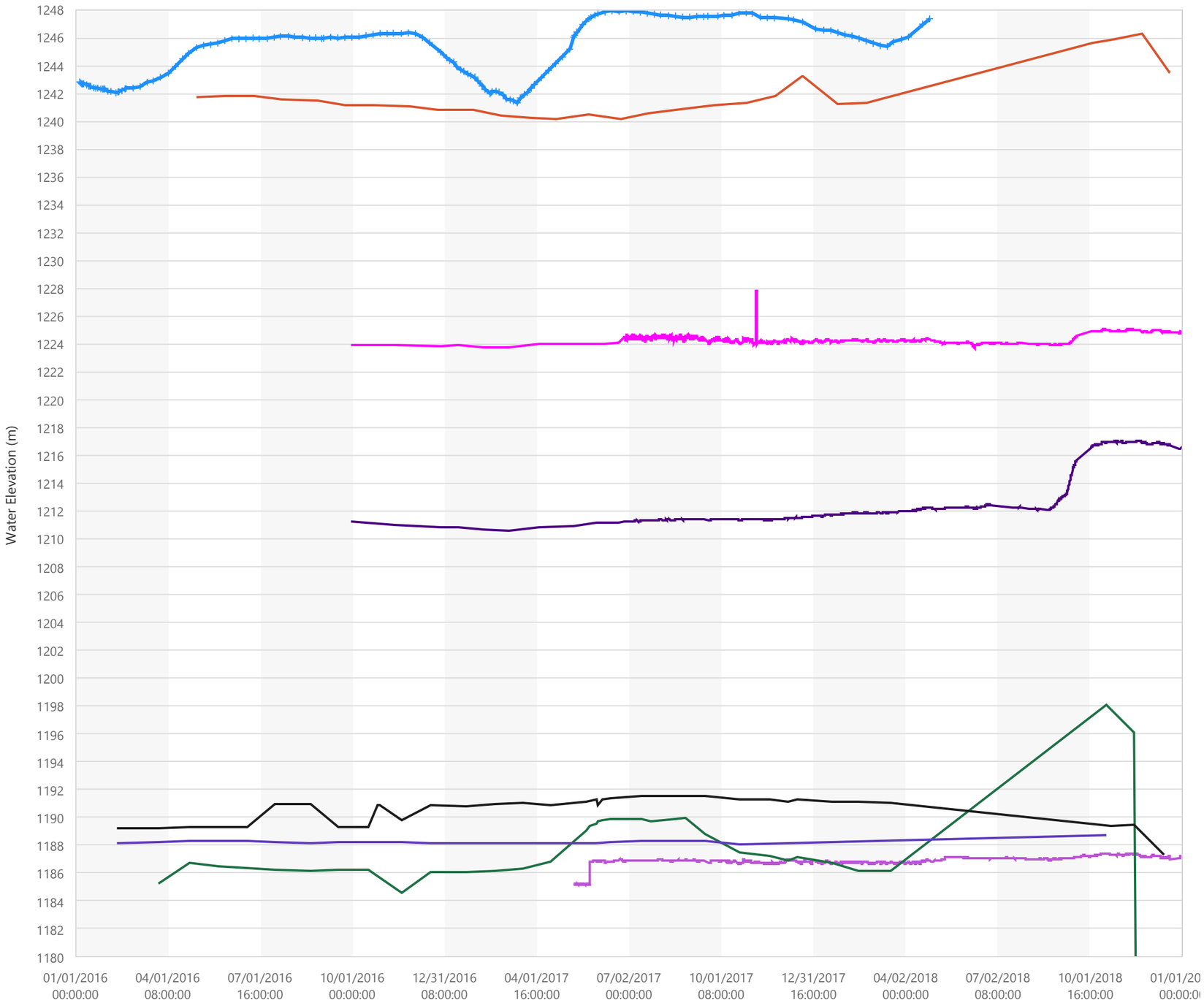
NORTH ABUTMENT - FOUNDATION ROCK


NORTH ABUTMENT
P11-06A,B
VWP16-8A,B,C / P16-8
VWP16-3A,B / P16-3
P13-11
P13-12
P13-13
P13-10
P12-2
P13-07
P01-4A TO D
20500E
P11-05A,B
P10-9A,B
P98-1A TO F
P96-1A
P13-05
P12-6
I92-5
P86-2004
P86-2005
I99-6
P99-3
P01-3A,B,C
I16-5
P11-04
VWP16-4A,B
VWP16-24 A
VWP16-1A,B,C
I16-1
I16-4
VWP19-4A
I19-04
VWP19-4B
P11-08A,B
VWP17-40
VWP17-12
VWP16-7A,B / P16-7
P17-12A,B
P12-1A,B
P11-07A,B
VWP16-6A,B,C / P16-6
3+600
3+400
3+900
3+800
1240
1250
1260

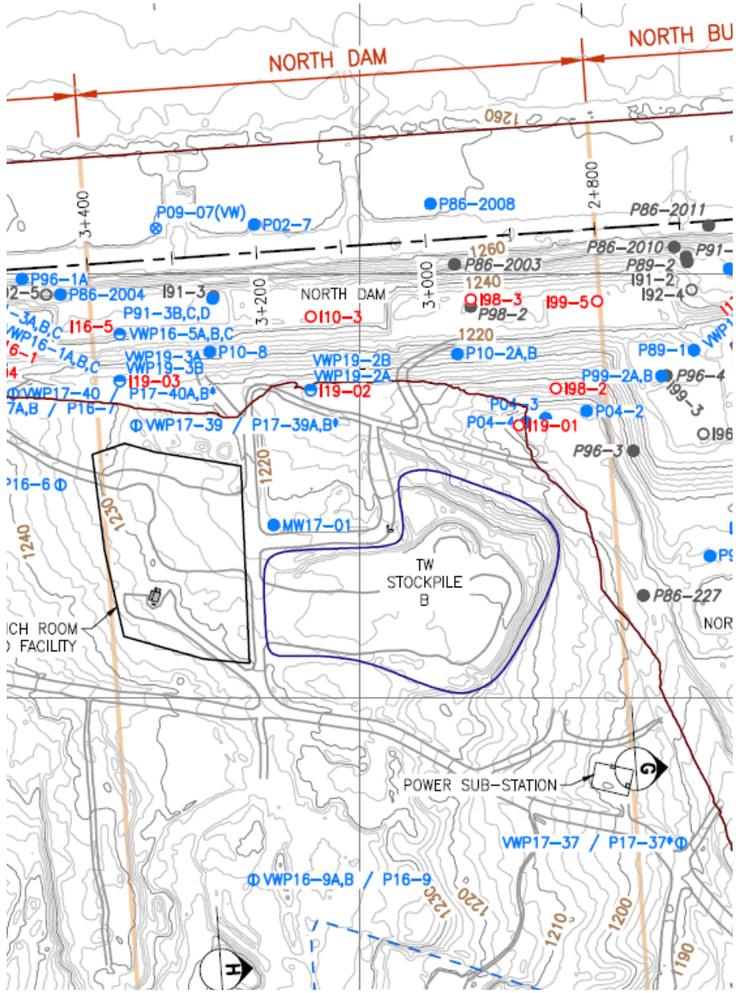

Water Elevation (m)
1248
1247
1246
1245
1244
1243
1242
1241
1240
1239
1238
1237
1236
1235
1234
1233
1232
1231
1230
1229
01/01/2016 00:00:00
04/01/2016 08:00:00
07/01/2016 16:00:00
10/01/2016 00:00:00
12/31/2016 08:00:00
04/01/2017 16:00:00
07/02/2017 00:00:00
10/01/2017 08:00:00
12/31/2017 16:00:00
04/02/2018 00:00:00
07/02/2018 08:00:00
10/01/2018 16:00:00
LL-VWP16-07A (Sedimentary) - Water Elevation (m)
LL-VWP11-08A (Volcanics) - Water Elevation (m)
LL-PondLevel - Raw3 ()
P01-4B - Water Elevation (m)
P01-4C - Water Elevation (m)
P01-4D - Water Elevation (m)
P98-1D - Water Elevation (m)
P98-1E - Water Elevation (m)
P98-1F - Water Elevation (m)
P99-3 - Water Elevation (m)
P01-3B - Water Elevation (m)
P01-3C - Water Elevation (m)
P11-8A - Water Elevation (m)
P86-2004 - Water Elevation (m)

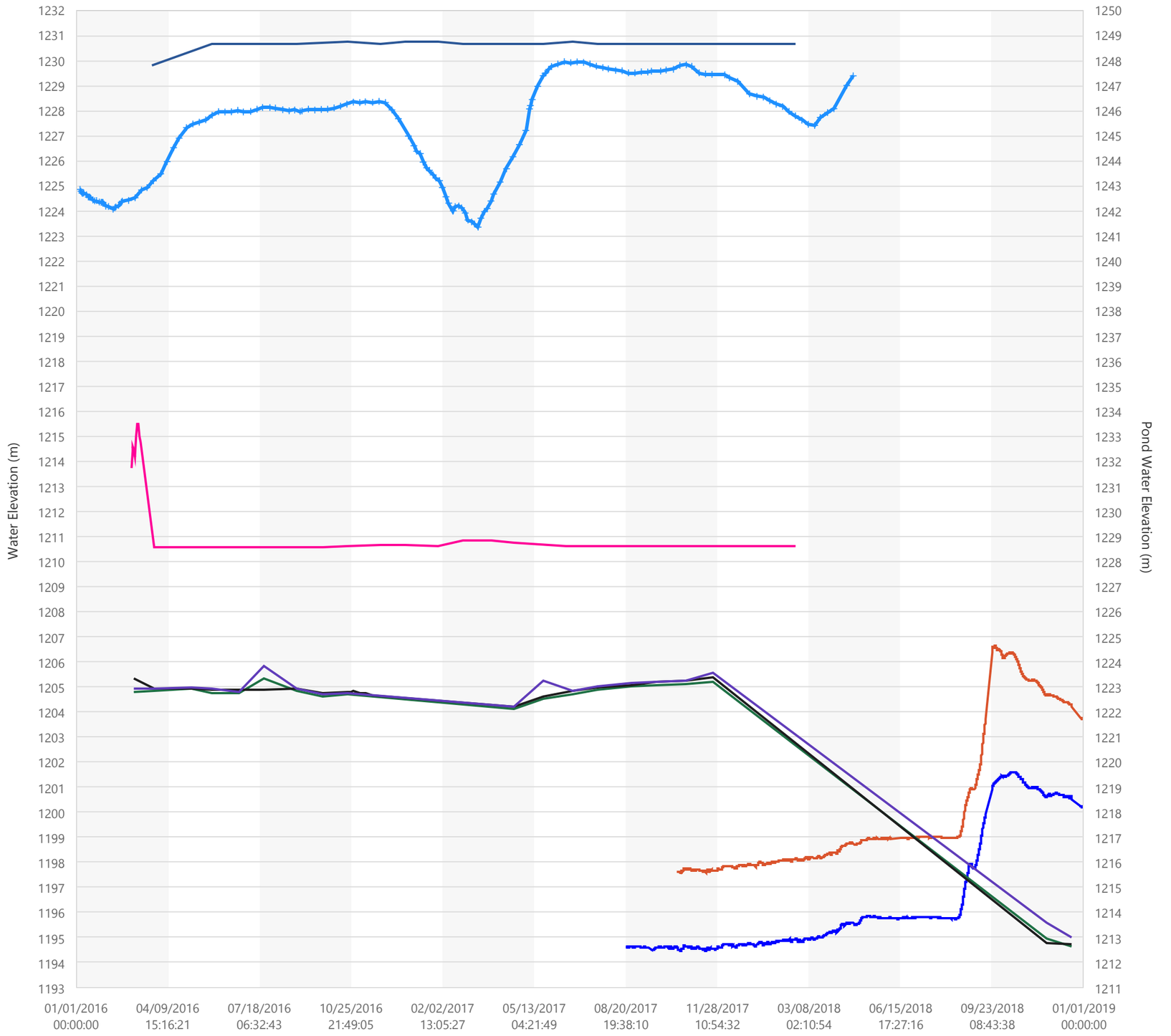
NORTH DAM - GLACIAL TILL, SAND, UPPER GLU


NORTH DAM
NORTH BU
1260
3+400
3+200
3+000
2+800
P09–07(VW)
P02–7
P86–2008
P86–2011
P86–2010
P86–2003
P86–2004
P89–2
P89–1
P96–1A
I91–3
I91–2
I92–4
I16–5
P91–3B,C,D
VWP16–5A,B,C
I10–3
I98–3
I99–5
P98–2
1240
1220
P10–8
P10–2A,B
VWP19–3A
VWP19–3B
VWP19–2B
VWP19–2A
I19–03
I19–02
P17–40A,B*
VWP17–40 / P16–7
VWP17–39 / P17–39A,B*
P99–2A,B
P96–4
I98–2
P04–3
P04–2
I19–01
P96–3
I96
MW17–01
1230
TW
STOCKPILE
B
P86–227
NOR
ICH ROOM
FACILITY
POWER SUB–STATION
VWP17–37 / P17–37*Φ
ΦVWP16–9A,B / P16–9
1210
1200
1190

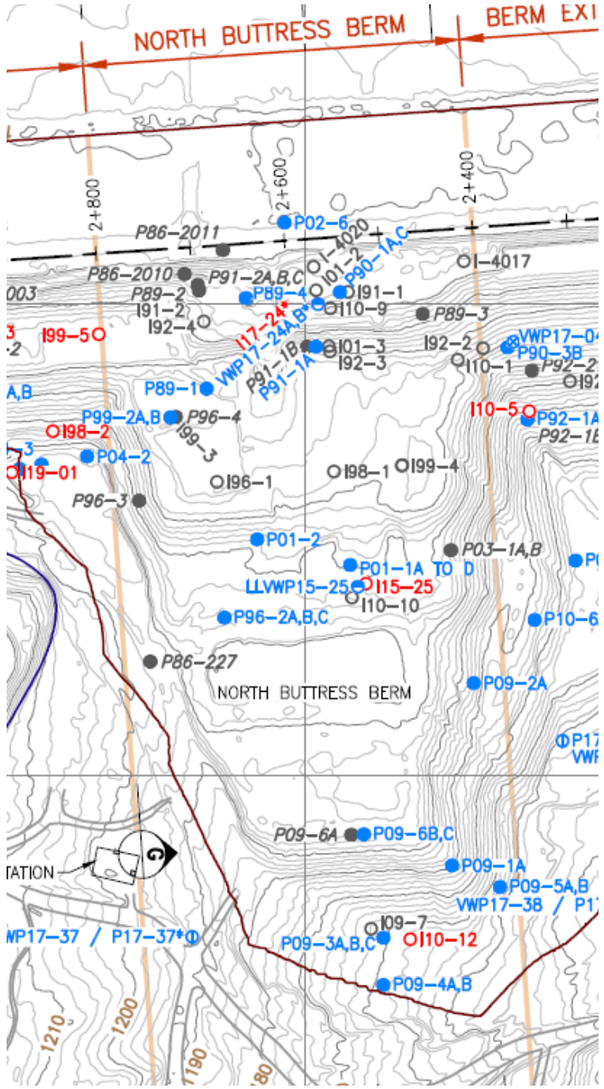

Water Elevation (m)
1248
1246
1244
1242
1240
1238
1236
1234
1232
1230
1228
1226
1224
1222
1220
1218
1216
1214
1212
1210
1208
1206
1204
1202
1200
1198
1196
1194
1192
1190
1188
1186
1184
1182
1180
01/01/2016 00:00:00
04/01/2016 08:00:00
07/01/2016 16:00:00
10/01/2016 00:00:00
12/31/2016 08:00:00
04/01/2017 16:00:00
07/02/2017 00:00:00
10/01/2017 08:00:00
12/31/2017 16:00:00
04/02/2018 00:00:00
07/02/2018 08:00:00
10/01/2018 16:00:00
LL-VWP16-05A (Glacial Till Stratisfied) - Water Elevation (m)
LL-VWP16-05B (Upper GLU) - Water Elevation (m)
LL-VWP04-4 (Glacial Till) - Water Elevation (m)
P02-7 - Water Elevation (m)
P04-2 - Water Elevation (m)
P04-3 - Water Elevation (m)
P04-4 - Water Elevation (m)
P09-07 (VW) - Water Elevation (m)
LL-PondLevel - Raw3 ()

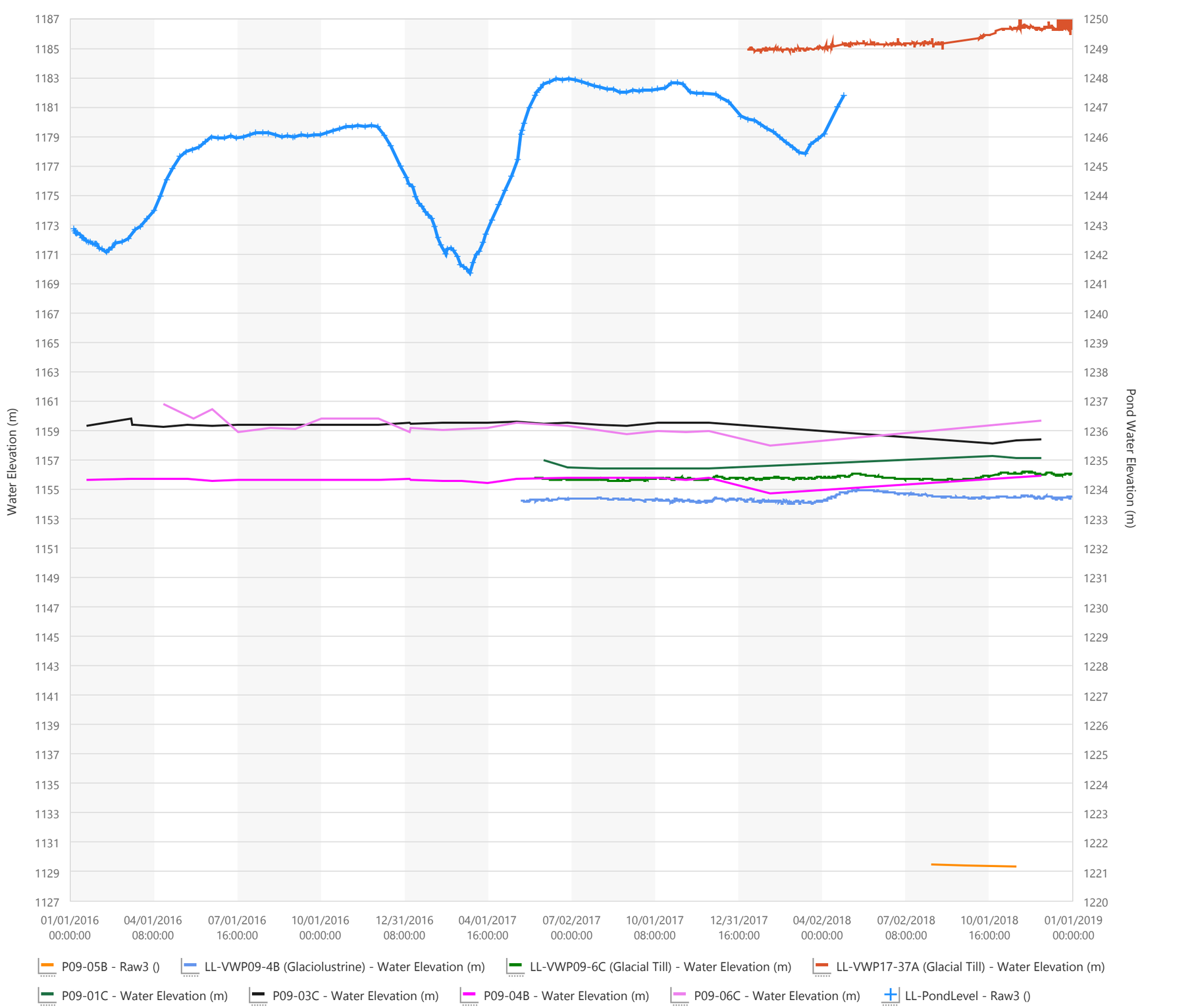
NORTH DAM - VOLCANICS


NORTH DAM
NORTH BU
1260
3+400
3+200
3+000
2+800
P09–07(VW)
P02–7
P86–2008
P86–2011
P86–2010
P91–
P89–2
I91–2
I92–4
P96–1A
P86–2004
I91–3
P91–3B,C,D
I16–5
VWP16–5A,B,C
P10–8
VWP19–3A
VWP19–3B
I19–03
P17–40A,B*
VWP17–40 / P16–7
VWP17–39 / P17–39A,B*
NORTH DAM
I10–3
I98–3
I99–5
P98–2
1240
1220
P10–2A,B
VWP19–2B
VWP19–2A
I19–02
P89–1
P96–4
P99–2A,B
I98–2
P04–3
P04–2
P04–1
I19–01
I96
P96–3
MW17–01
TW
STOCKPILE
B
P86–227
NOR
ICH ROOM
FACILITY
POWER SUB–STATION
VWP17–37 / P17–37*Φ
Φ VWP16–9A,B / P16–9
1230
1220
1210
1200
1190

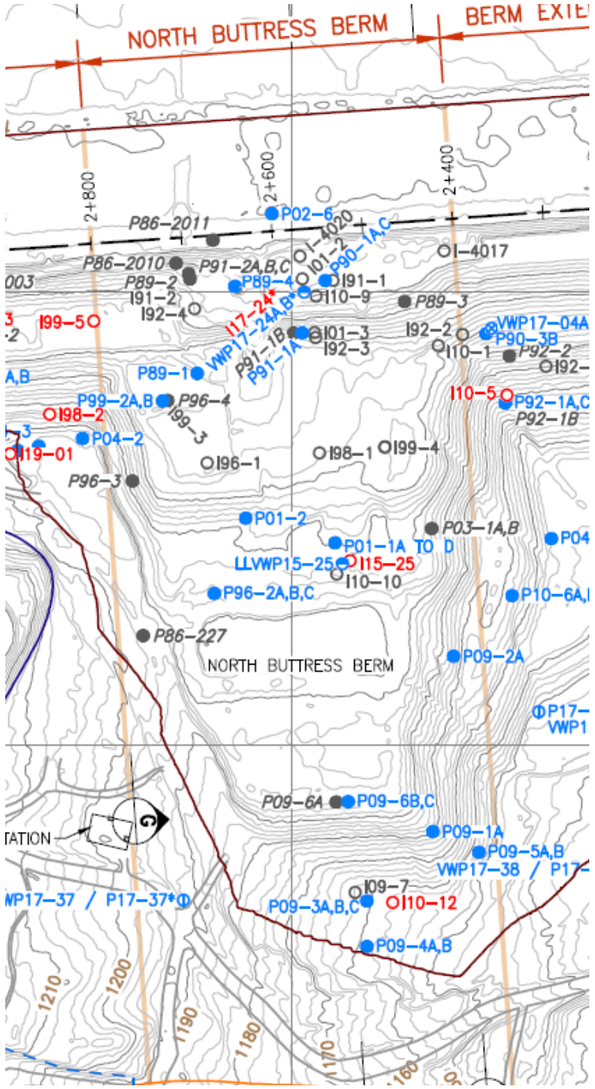

Water Elevation (m)
Pond Water Elevation (m)
1232
1231
1230
1229
1228
1227
1226
1225
1224
1223
1222
1221
1220
1219
1218
1217
1216
1215
1214
1213
1212
1211
1210
1209
1208
1207
1206
1205
1204
1203
1202
1201
1200
1199
1198
1197
1196
1195
1194
1193
1250
1249
1248
1247
1246
1245
1244
1243
1242
1241
1240
1239
1238
1237
1236
1235
1234
1233
1232
1231
1230
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1226
1225
1224
1223
1222
1221
1220
1219
1218
1217
1216
1215
1214
1213
1212
1211
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04/09/2016 15:16:21
07/18/2016 06:32:43
10/25/2016 21:49:05
02/02/2017 13:05:27
05/13/2017 04:21:49
08/20/2017 19:38:10
11/28/2017 10:54:32
03/08/2018 02:10:54
06/15/2018 17:27:16
09/23/2018 08:43:38
01/01/2019 00:00:00
LL-VWP10-2A (Volcanics Upper) - Water Elevation (m)
LL-VWP10-2B (Volcanics Upper) - Water Elevation (m)
P86-2008 - Water Elevation (m)
P91-3B - Water Elevation (m)
P91-3C - Water Elevation (m)
P91-3D - Water Elevation (m)
P10-08 - Water Elevation (m)
LL-PondLevel - Raw3 ()

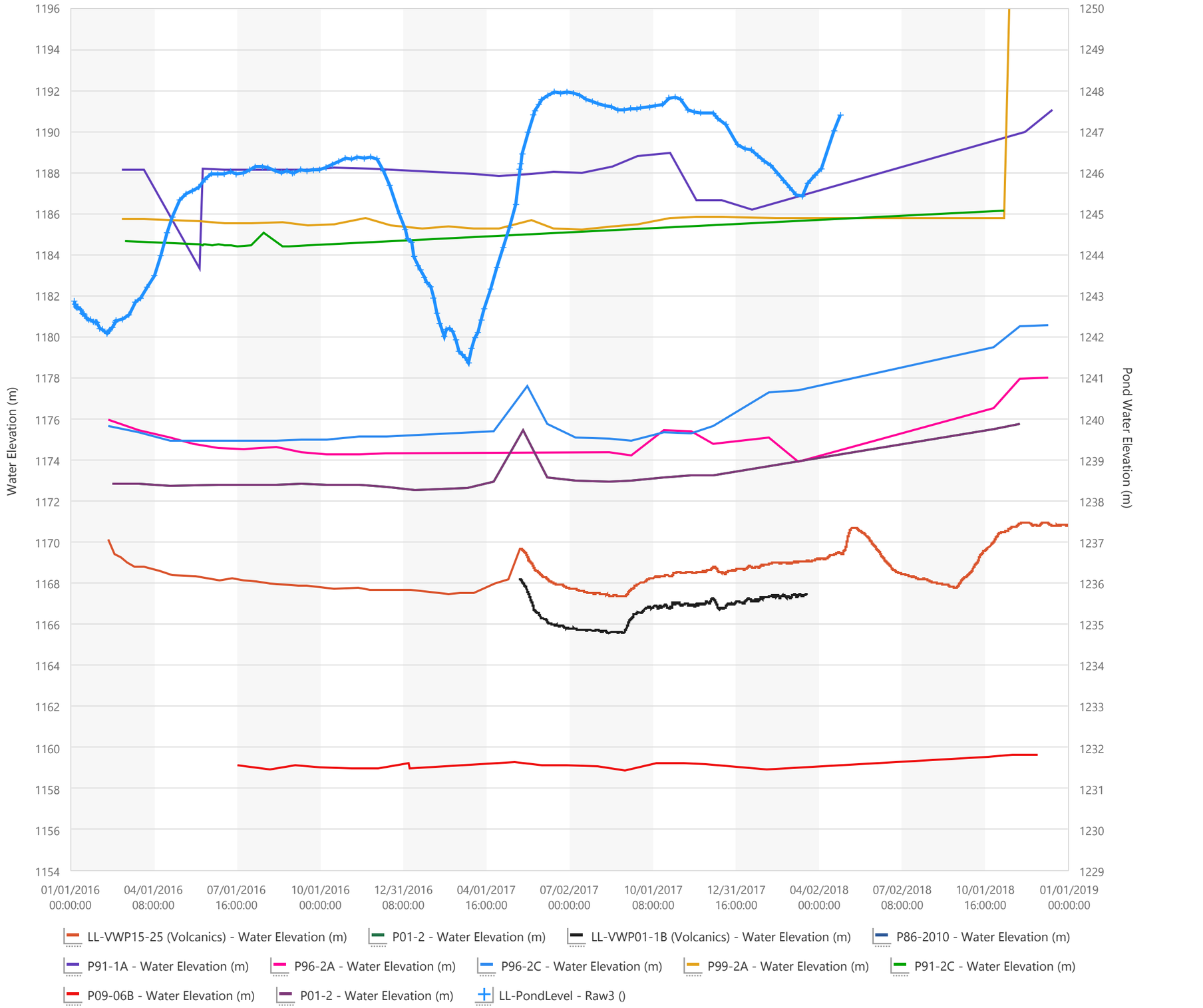
NORTH BUTTRESS BERM - OVERBURDEN


NORTH BUTTRESS BERM
BERM EXT
2+800
2+600
2+400
P86–2011
P02–6
P86–2010
P91–2A,B,C
P90–1A,C
I01–4020
I01–2
I–4017
P89–2
P89–4
I91–1
I91–2
I92–4
I10–9
P89–3
I99–5
I17–24
I17–24A,B
I01–3
I92–3
I92–2
VWP17–04
P90–3B
I10–1
P92–2
P91–1B
P91–1A
P89–1
VWP17–24
I10–5
P92–1A
P92–1B
P99–2A,B
P96–4
I98–2
I99–3
P04–2
I19–01
I96–1
I98–1
I99–4
P96–3
P01–2
P03–1A,B
P01–1A TO D
LLVWP15–25
I15–25
I10–10
P96–2A,B,C
P10–6
P86–227
NORTH BUTTRESS BERM
P09–2A
P09–6A
P09–6B,C
P09–1A
P09–5A,B
VWP17–38
I09–7
I10–12
P09–3A,B,C
P09–4A,B
1210
1200
1190
1180

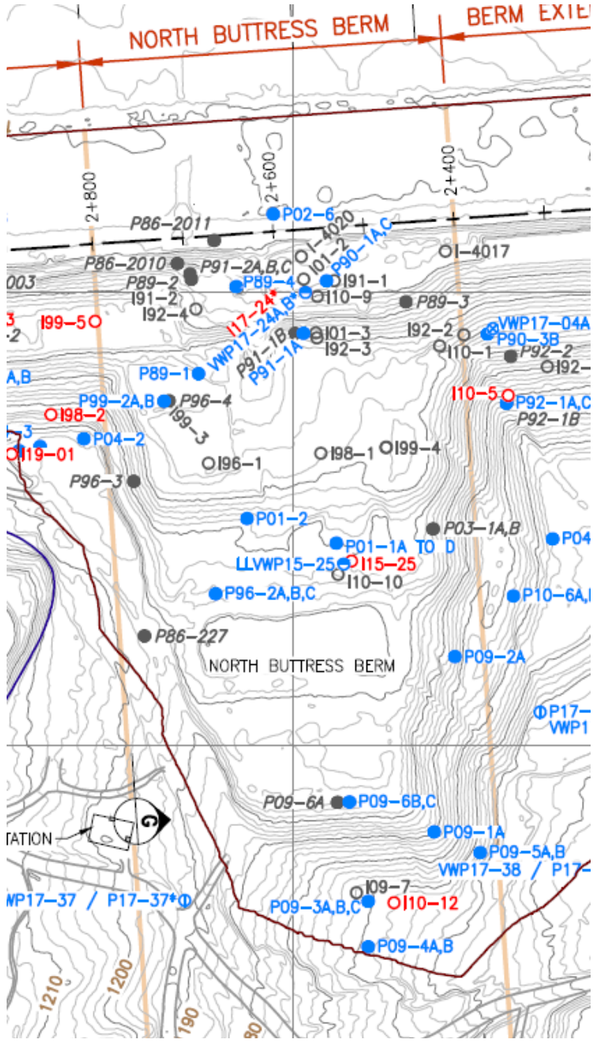

Water Elevation (m)
Pond Water Elevation (m)
1187
1185
1183
1181
1179
1177
1175
1173
1171
1169
1167
1165
1163
1161
1159
1157
1155
1153
1151
1149
1147
1145
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1141
1139
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1133
1131
1129
1127
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1234
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04/01/2016 08:00:00
07/01/2016 16:00:00
10/01/2016 00:00:00
12/31/2016 08:00:00
04/01/2017 16:00:00
07/02/2017 00:00:00
10/01/2017 08:00:00
12/31/2017 16:00:00
04/02/2018 00:00:00
07/02/2018 08:00:00
10/01/2018 16:00:00
01/01/2019 00:00:00
P09-05B - Raw3 ()
LL-VWP09-4B (Glaciolustrine) - Water Elevation (m)
LL-VWP09-6C (Glacial Till) - Water Elevation (m)
LL-VWP17-37A (Glacial Till) - Water Elevation (m)
P09-01C - Water Elevation (m)
P09-03C - Water Elevation (m)
P09-04B - Water Elevation (m)
P09-06C - Water Elevation (m)
LL-PondLevel - Raw3 ()

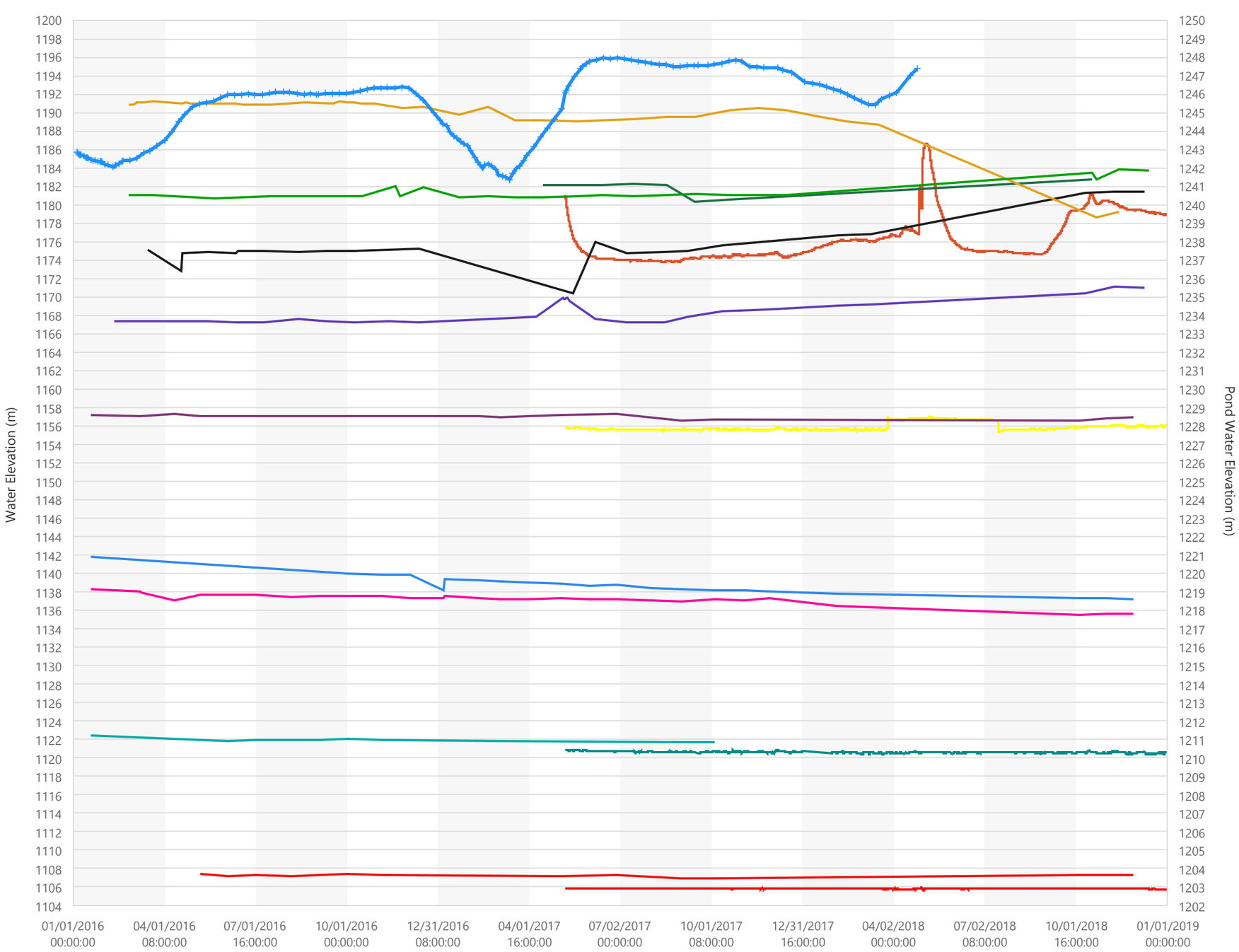
NORTH BUTTRESS BERM - VOLCANICS


NORTH BUTTRESS BERM
BERM EXTE
2+800
2+600
2+400
P86-2011
P02-6
P86-2010
P91-2A,B,C
P89-4
P89-2
I91-2
I92-4
I91-1
I10-9
P89-3
I99-5
I17-24*
I01-3
I92-3
I92-2
VWP17-04A
P90-3B
I10-1
P92-2
P89-1
VWP17-1A
P91-1B
P91-1A
I10-5
P92-1A,C
P92-1B
P99-2A,B
P96-4
I98-2
P99-3
P04-2
I19-01
I96-1
I98-1
I99-4
P96-3
P01-2
P03-1A,B
P04
P01-1A TO D
LLVWP15-25
I15-25
I10-10
P96-2A,B,C
P10-6A
P86-227
NORTH BUTTRESS BERM
P09-2A
P09-6A
P09-6B,C
P09-1A
P09-5A,B
VWP17-38 / P17
I09-7
P09-3A,B,C
I10-12
P09-4A,B
1210
1200
1190
1180
1170

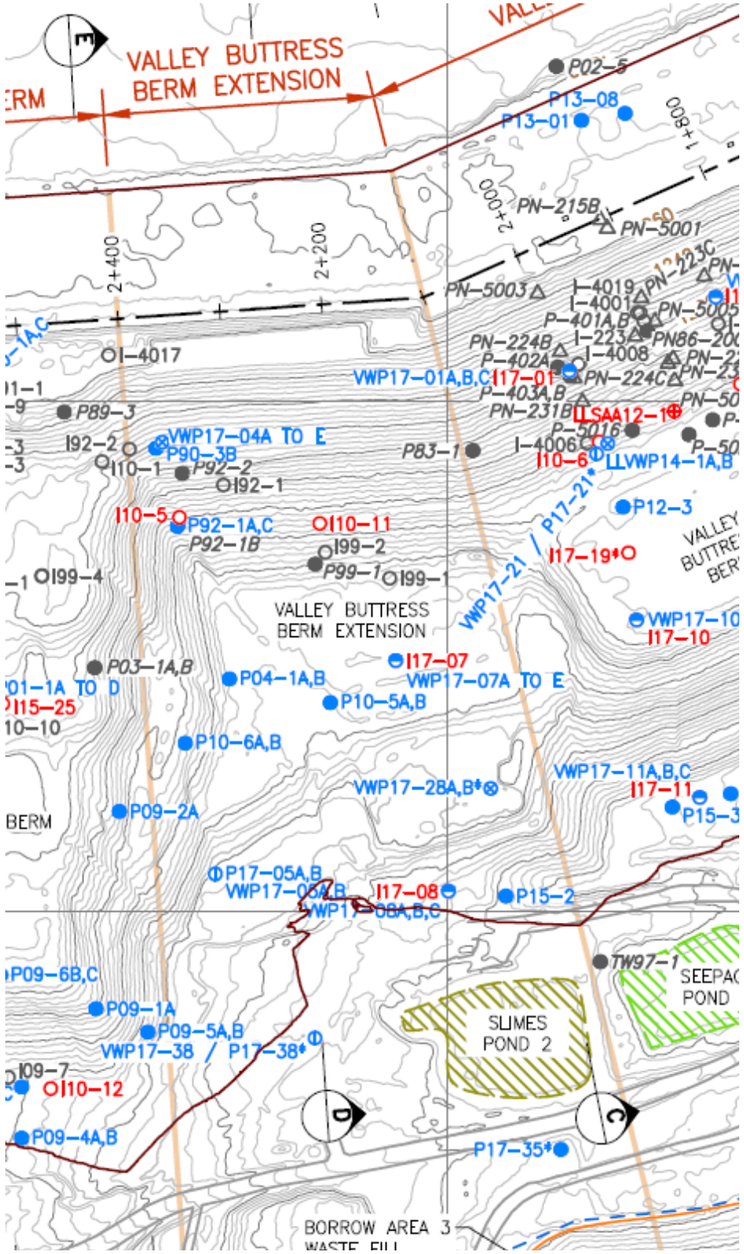

Water Elevation (m)
Pond Water Elevation (m)
1196
1194
1192
1190
1188
1186
1184
1182
1180
1178
1176
1174
1172
1170
1168
1166
1164
1162
1160
1158
1156
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1240
1239
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1237
1236
1235
1234
1233
1232
1231
1230
1229
01/01/2016 00:00:00
04/01/2016 08:00:00
07/01/2016 16:00:00
10/01/2016 00:00:00
12/31/2016 08:00:00
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10/01/2017 08:00:00
12/31/2017 16:00:00
04/02/2018 00:00:00
07/02/2018 08:00:00
10/01/2018 16:00:00
01/01/2019 00:00:00
LL-VWP15-25 (Volcanics) - Water Elevation (m)
P01-2 - Water Elevation (m)
LL-VWP01-1B (Volcanics) - Water Elevation (m)
P86-2010 - Water Elevation (m)
P91-1A - Water Elevation (m)
P96-2A - Water Elevation (m)
P96-2C - Water Elevation (m)
P99-2A - Water Elevation (m)
P91-2C - Water Elevation (m)
P09-06B - Water Elevation (m)
P01-2 - Water Elevation (m)
LL-PondLevel - Raw3 ()

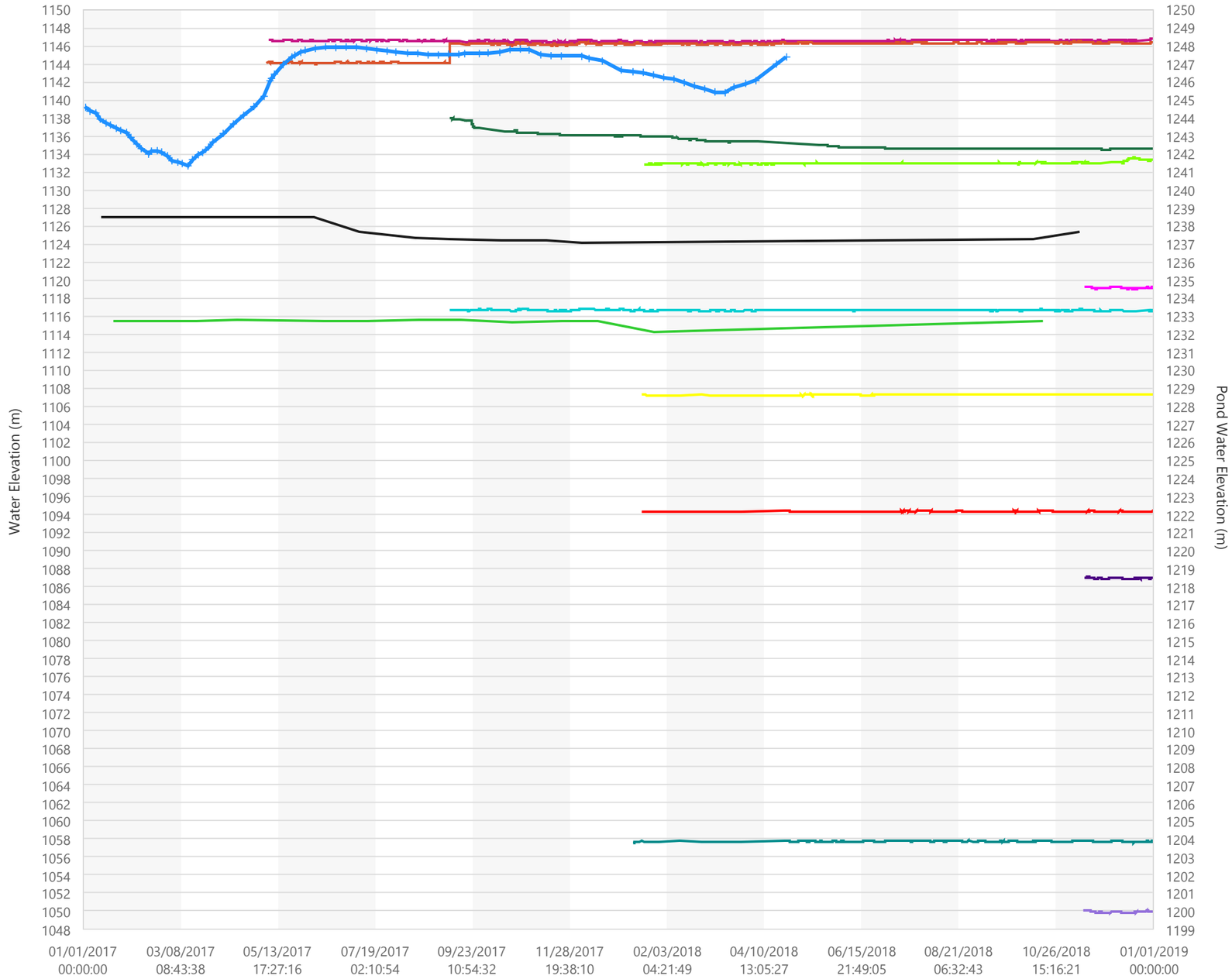
NORTH BUTTRESS BERM - SEDIMENTARY


NORTH BUTTRESS BERM
BERM EXTE
2+800
2+600
2+400
P86-2011
P02-6
P86-2010
P91-2A,B,C
P89-4
I91-1
I91-2
I92-4
I99-5
I17-2
I01-3
I92-3
P89-3
I92-2
VWP17-04A
P90-3B
P92-2
I92-
P89-1
VWP17-24A,B
P91-1B
P91-1A
I10-1
I10-5
P92-1A,C
P92-1B
P99-2A,B
P96-4
I98-2
I99-3
P04-2
I19-01
I96-1
I98-1
I99-4
P96-3
P01-2
P03-1A,B
P04
P01-1A TO D
LLVWP15-25
I15-25
I10-10
P96-2A,B,C
P10-6A,
P86-227
NORTH BUTTRESS BERM
P09-2A
ΦP17-
VWP1
P09-6A
P09-6B,C
P09-1A
P09-5A,B
VWP17-38 / P17-
I09-7
P09-3A,B,C
I10-12
P09-4A,B
TATION
WP17-37 / P17-37*Φ
1210
1200
190

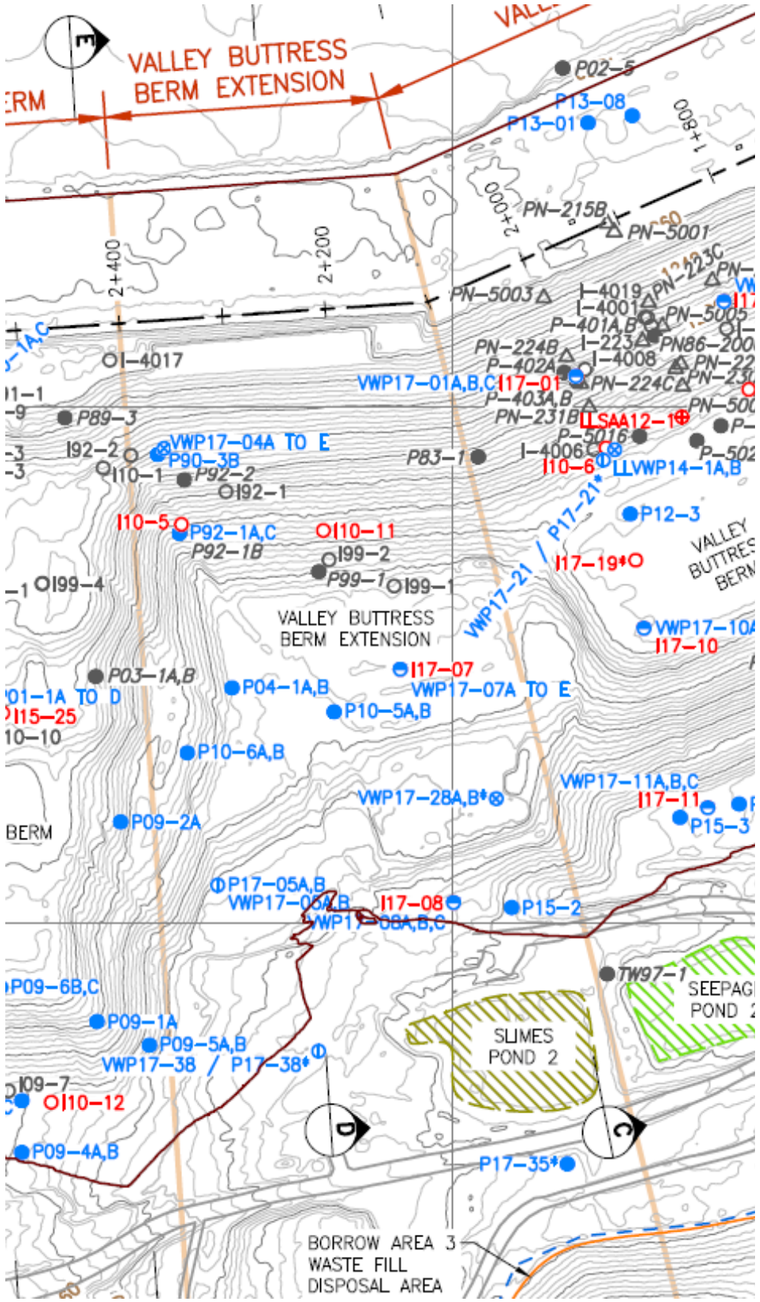

Water Elevation (m)
Pond Water Elevation (m)
1200
1198
1196
1194
1192
1190
1188
1186
1184
1182
1180
1178
1176
1174
1172
1170
1168
1166
1164
1162
1160
1158
1156
1154
1152
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1136
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1132
1130
1128
1126
1124
1122
1120
1118
1116
1114
1112
1110
1108
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1234
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1205
1204
1203
1202
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04/01/2016 08:00:00
07/01/2016 16:00:00
10/01/2016 00:00:00
12/31/2016 08:00:00
04/01/2017 16:00:00
07/02/2017 00:00:00
10/01/2017 08:00:00
12/31/2017 16:00:00
04/02/2018 00:00:00
07/02/2018 08:00:00
10/01/2018 16:00:00
01/01/2019 00:00:00
LL-VWP09-1A (Sedimentary) - Water Elevation (m)
LL-VWP09-3B (Sedimentary) - Water Elevation (m)
LL-VWP09-5A (Sedimentary) - Water Elevation (m)
LL-VWP96-02B (Sedimentry) - Water Elevation (m)
P89-4 - Water Elevation (m)
P96-2B - Water Elevation (m)
P01-1C - Water Elevation (m)
P09-03A - Water Elevation (m)
P09-04A - Water Elevation (m)
P90-1C - Water Elevation (m)
P99-2B - Water Elevation (m)
P09-01A - Water Elevation (m)
P09-03B - Water Elevation (m)
P09-05A - Water Elevation (m)
LL-PondLevel - Raw3 ()

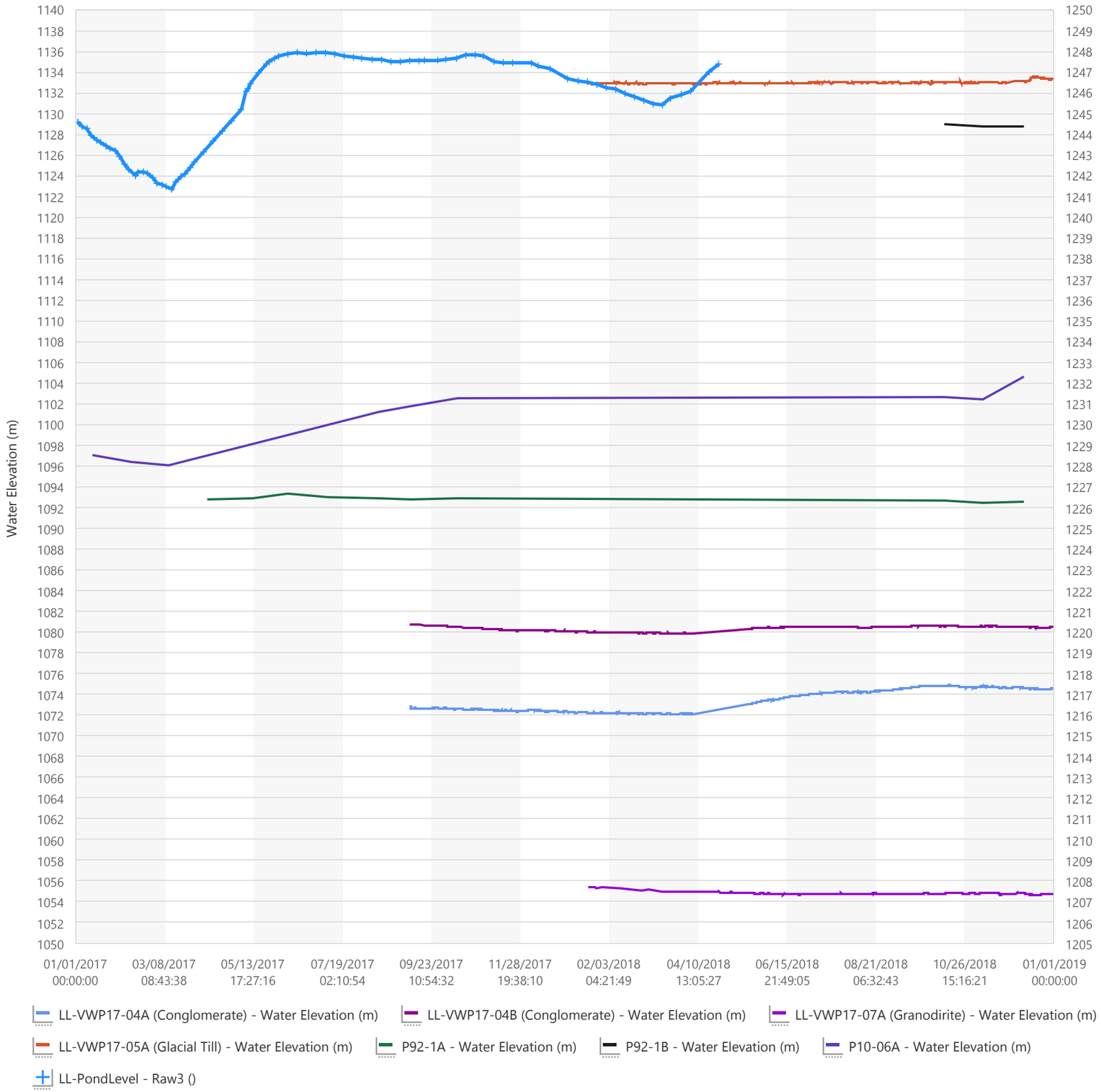
VALLEY BUTTRESS BERM EXTENSION - OVERBURDEN AND DAM FILL


VALLEY BUTTRESS
BERM EXTENSION
VALLEY BUTTRESS
BERM EXTENSION
SLIMES
POND 2
SEEPAGE
POND
BORROW AREA 3
P02–5
P13–08
P13–01
PN–215B
PN–5001
PN–5003
I–4019
I–4001
P–401A,B
PN–224B
P–402A
I–4008
PN–224C
P–403A,B
PN–231B
P–5016
I–4006
I–4017
VWP17–01A,B,C
I17–01
LLSAA12–1
I10–6
LLVWP14–1A,B
P83–1
P89–3
I92–2
VWP17–04A TO E
P90–3B
I10–1
P92–2
I92–1
I10–5
P92–1A,C
P92–1B
I10–11
I99–2
P99–1
I99–1
I99–4
P12–3
P17–21
VWP17–21
I17–19
VWP17–10
I17–10
I17–07
VWP17–07A TO E
P03–1A,B
P04–1A,B
P10–5A,B
I15–25
P10–6A,B
VWP17–28A,B
VWP17–11A,B,C
I17–11
P15–3
P09–2A
P17–05A,B
VWP17–08A,B
I17–08
P15–2
TW97–1
P09–6B,C
P09–1A
P09–5A,B
VWP17–38 / P17–38
I09–7
I10–12
P09–4A,B
P17–35
2+000
2+200
2+400
1+800

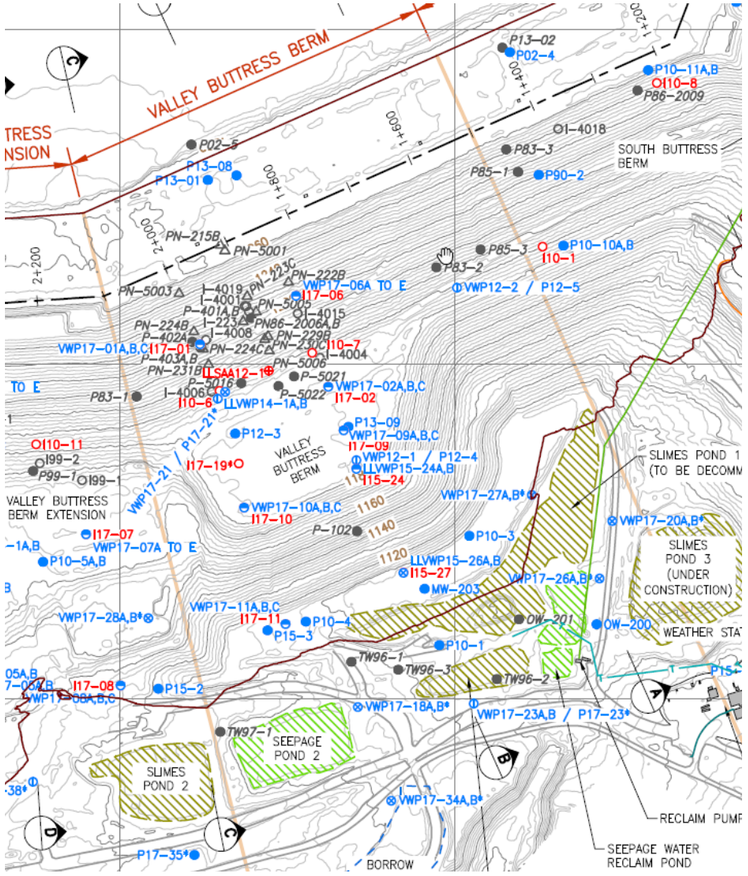

Water Elevation (m)
Pond Water Elevation (m)
1150
1148
1146
1144
1142
1140
1138
1136
1134
1132
1130
1128
1126
1124
1122
1120
1118
1116
1114
1112
1110
1108
1106
1104
1102
1100
1098
1096
1094
1092
1090
1088
1086
1084
1082
1080
1078
1076
1074
1072
1070
1068
1066
1064
1062
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1054
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1205
1204
1203
1202
1201
1200
1199
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03/08/2017 08:43:38
05/13/2017 17:27:16
07/19/2017 02:10:54
09/23/2017 10:54:32
11/28/2017 19:38:10
02/03/2018 04:21:49
04/10/2018 13:05:27
06/15/2018 21:49:05
08/21/2018 06:32:43
10/26/2018 15:16:21
01/01/2019 00:00:00
LL-VWP17-04D (Lower Sand and Gravel) - Water Elevation (m)
LL-VWP17-05A (Glacial Till) - Water Elevation (m)
LL-VWP17-07B (Lower S&G - Glaciofluvial) - Water Elevation (m)
LL-VWP17-07C (Lower S&G - Glaciofluvial) - Water Elevation (m)
LL-VWP17-07D (Glacial Till) - Water Elevation (m)
LL-VWP17-08A (Glacial Till (Silt)) - Water Elevation (m)
LL-VWP17-08B (Lower S&G) - Water Elevation (m)
LL-VWP17-08C (Glacial Till) - Water Elevation (m)
LL-VWP04-1A (Glacial Till) - Water Elevation (m)
LL-VWP04-1B (Sand and Gravel) - Water Elevation (m)
LL-VWP17-04E (Glacial Till) - Water Elevation (m)
P10-05B - Water Elevation (m)
P04-1B - Water Elevation (m)
P04-1A - Water Elevation (m)
LL-PondLevel - Raw3 ()
P15-2 - Water Elevation (m)

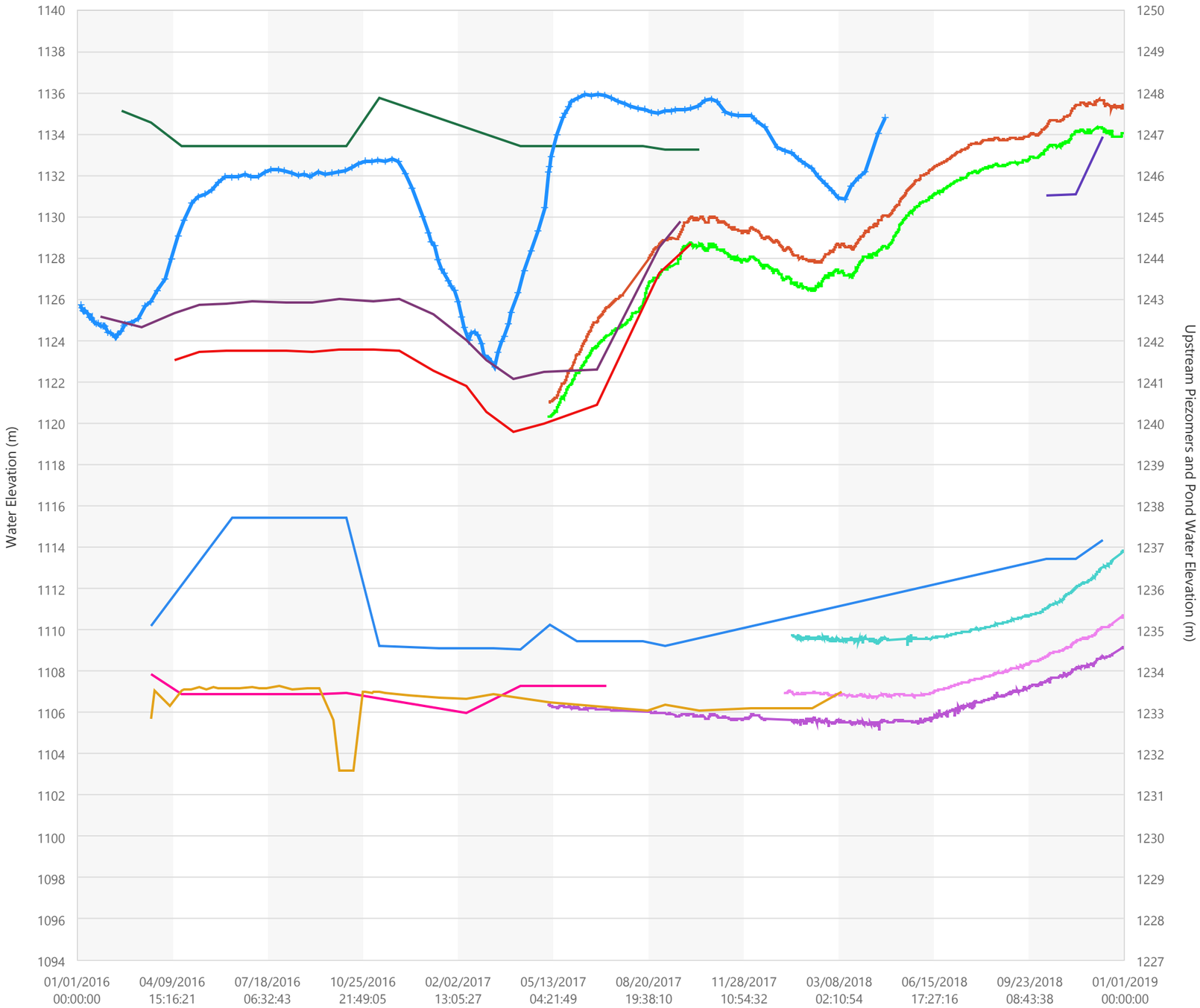
VALLEY BUTTRESS BERM EXTENSION - FOUNDATION ROCK


VALLEY BUTTRESS BERM EXTENSION
VALLEY BUTTRESS BERM EXTENSION
SLIMES POND 2
BORROW AREA 3 WASTE FILL DISPOSAL AREA
SEEPAGE POND 2
P02-5
P13-08
P13-01
PN-215B
PN-5001
PN-5003
I-4019
I-4001
P-401A,B
PN-5005
PN-224B
I-223
PN86-200
P-402A
I-4008
PN-224C
P-403A,B
PN-231B
P-5016
I-4006
I-4017
VWP17-01A,B,C
I17-01
LLSAA12-1
I10-6
LLVWP14-1A,B
P83-1
P89-3
I92-2
VWP17-04A TO E
P90-3B
I10-1
P92-2
I92-1
I10-5
P92-1A,C
P92-1B
I10-11
I99-2
P99-1
I99-1
I99-4
P12-3
P17-21
I17-19
VWP17-10A
I17-10
P03-1A,B
P04-1A,B
I17-07
VWP17-07A TO E
P10-5A,B
P10-6A,B
VWP17-11A,B,C
I17-11
P15-3
VWP17-28A,B
P09-2A
P17-05A,B
VWP17-05A,B
I17-08
VWP17-08A,B,C
P15-2
TW97-1
P09-6B,C
P09-1A
P09-5A,B
VWP17-38 / P17-38
I09-7
I10-12
P09-4A,B
P17-35
1+600
2+000
2+200
2+400

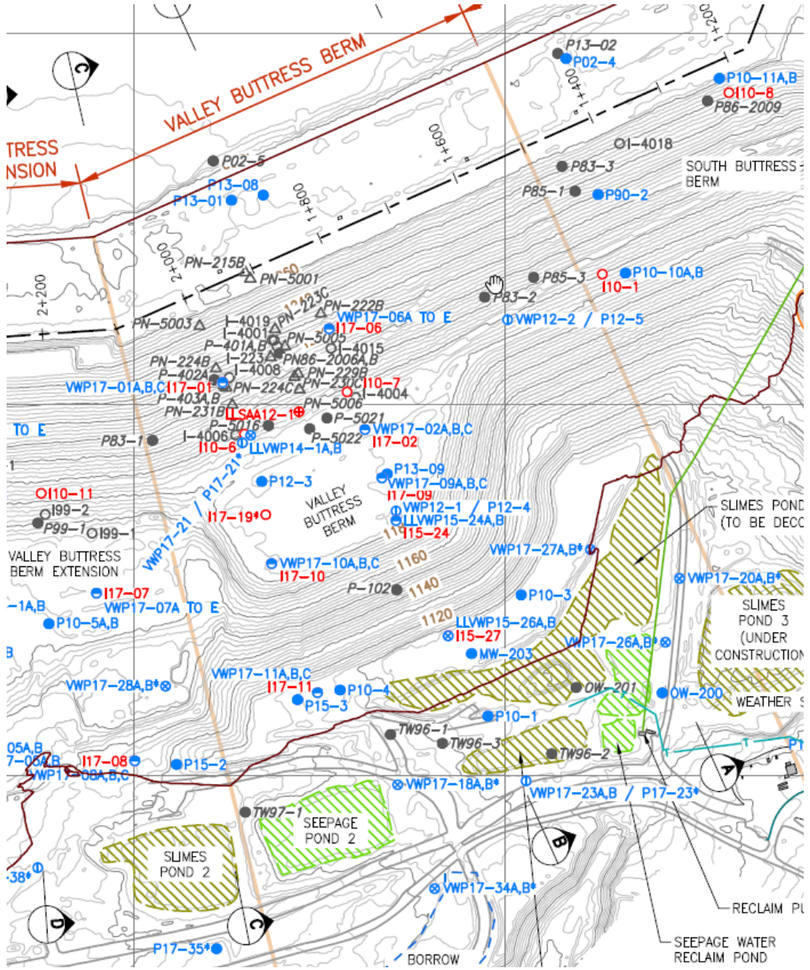

Water Elevation (m)
Pond Water Elevation (m)
1140 1138 1136 1134 1132 1130 1128 1126 1124 1122 1120 1118 1116 1114 1112 1110 1108 1106 1104 1102 1100 1098 1096 1094 1092 1090 1088 1086 1084 1082 1080 1078 1076 1074 1072 1070 1068 1066 1064 1062 1060 1058 1056 1054 1052 1050
1250 1249 1248 1247 1246 1245 1244 1243 1242 1241 1240 1239 1238 1237 1236 1235 1234 1233 1232 1231 1230 1229 1228 1227 1226 1225 1224 1223 1222 1221 1220 1219 1218 1217 1216 1215 1214 1213 1212 1211 1210 1209 1208 1207 1206 1205
01/01/2017 00:00:00
03/08/2017 08:43:38
05/13/2017 17:27:16
07/19/2017 02:10:54
09/23/2017 10:54:32
11/28/2017 19:38:10
02/03/2018 04:21:49
04/10/2018 13:05:27
06/15/2018 21:49:05
08/21/2018 06:32:43
10/26/2018 15:16:21
01/01/2019 00:00:00
LL-VWP17-04A (Conglomerate) - Water Elevation (m)
LL-VWP17-04B (Conglomerate) - Water Elevation (m)
LL-VWP17-07A (Granodirite) - Water Elevation (m)
LL-VWP17-05A (Glacial Till) - Water Elevation (m)
P92-1A - Water Elevation (m)
P92-1B - Water Elevation (m)
P10-06A - Water Elevation (m)
LL-PondLevel - Raw3 ()

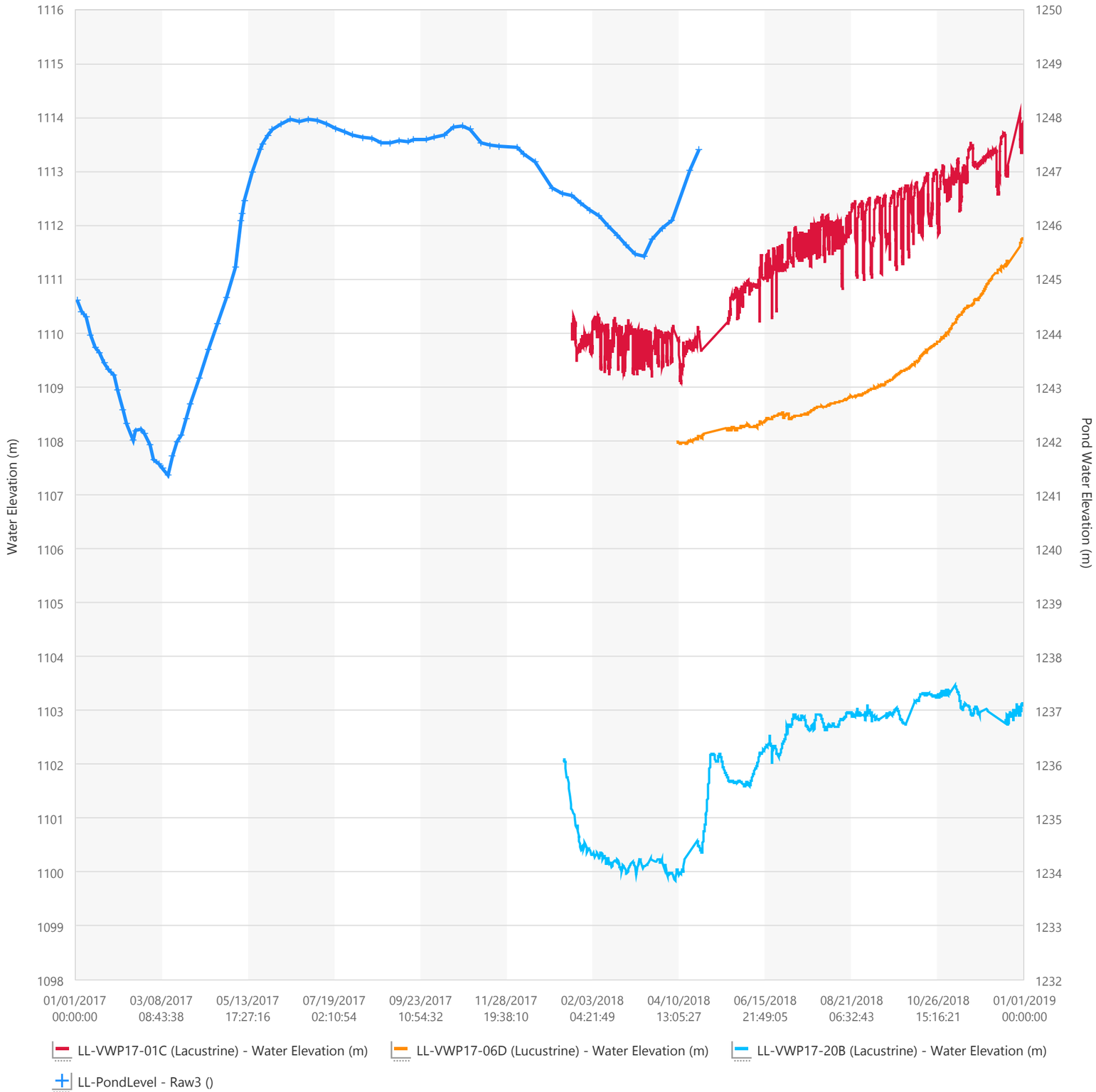
VALLEY BUTTRESS BERM - DAM FILL


VALLEY BUTTRESS BERM
SOUTH BUTTRESS BERM
VALLEY BUTTRESS BERM EXTENSION
VALLEY BUTTRESS BERM
SLIMES POND 1 (TO BE DECOMM
SLIMES POND 3 (UNDER CONSTRUCTION)
WEATHER STA
SEEPAGE POND 2
SLIMES POND 2
RECLAIM PUMF
SEEPAGE WATER RECLAIM POND
BORROW
P13-02
P02-4
P10-11A,B
I10-8
P86-2009
I-4018
P83-3
P85-1
P90-2
P02-5
P13-08
P13-01
PN-215B
PN-5001
P85-3
P10-10A,B
I10-1
P83-2
PN-5003
I-4019
PN-222C
PN-222B
VWP17-06A TO E
VWP12-2 / P12-5
I17-06
I-4015
I-4001A
PN-5005
P-401A,B
PN86-2006A,B
PN-224B
I-4023
I-4008
P-402A
PN-229B
PN-224C
PN-230
I10-7
I-4004
VWP17-01A,B,C
I17-01
P-403A,B
PN-5008
PN-231B
I-SAA12-1
P-5021
P-5018
VWP17-02A,B,C
P83-1
I-4006
I10-6
LLWP14-1A,B
P-5022
I17-02
P13-09
VWP17-09A,B,C
P12-3
I17-09
VWP12-1 / P12-4
LLVWP15-24A,B
I17-19*
I15-24
I10-11
I99-2
I99-1
P99-1
VWP17-27A,B*
VWP17-10A,B,C
I17-10
1160
P-102
1140
P10-3
VWP17-20A,B*
I17-07
VWP17-07A TO E
P10-5A,B
1120
LLVWP15-26A,B
I15-27
MW-203
VWP17-26A,B*
VWP17-28A,B*
VWP17-11A,B,C
I17-11
P10-4
P15-3
OW-201
OW-200
P10-1
TW96-1
TW96-3
TW96-2
I17-08
P15-2
VWP17-18A,B*
VWP17-23A,B / P17-23*
TW97-1
P17-35*
VWP17-34A,B*
A
B
C
D

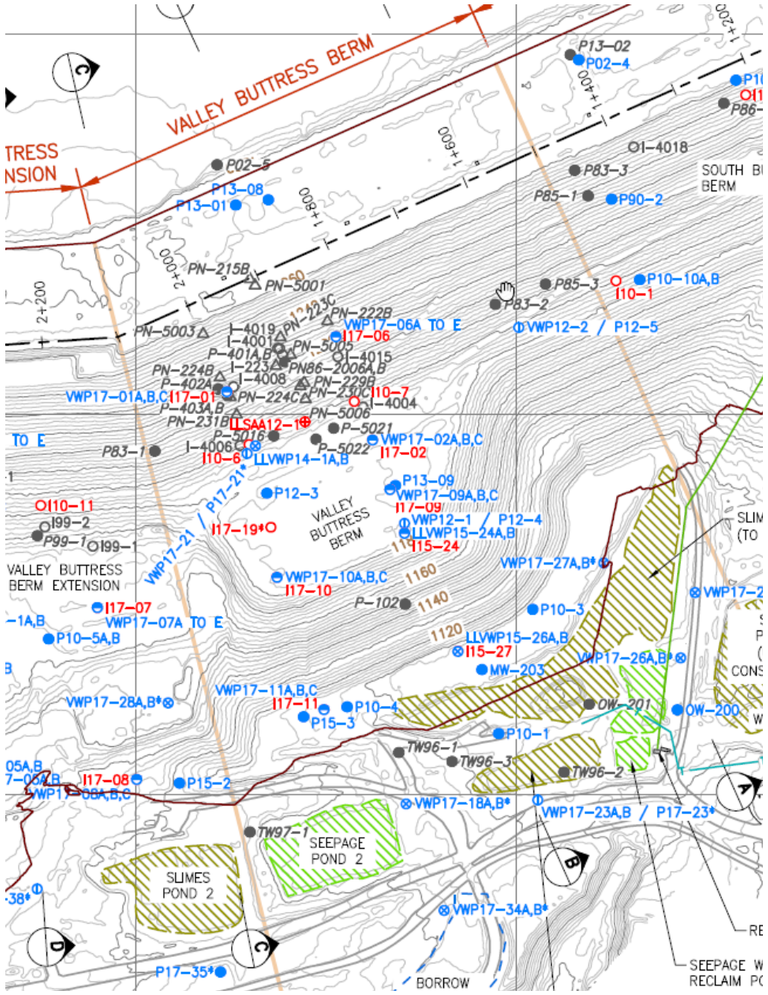

Water Elevation (m)
Upstream Piezomers and Pond Water Elevation (m)
1140
1138
1136
1134
1132
1130
1128
1126
1124
1122
1120
1118
1116
1114
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1108
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1100
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04/09/2016 15:16:21
07/18/2016 06:32:43
10/25/2016 21:49:05
02/02/2017 13:05:27
05/13/2017 04:21:49
08/20/2017 19:38:10
11/28/2017 10:54:32
03/08/2018 02:10:54
06/15/2018 17:27:16
09/23/2018 08:43:38
01/01/2019 00:00:00
LL-VWP17-02C (S&G Drainage Blanket) - Water Elevation (m)
LL-VWP17-06E (S&G Drainage Blanket) - Water Elevation (m)
LL-VWP13-09 (S&G Drainage Blanket) - Water Elevation (m)
LL-VWP13-01 (Upstream Sand) - Water Elevation (m)
LL-VWP13-08m (Upstream Sand) - Water Elevation (m)
P83-1 - Water Elevation (m)
LL-PondLevel - Raw3 ()
P83-2 - Water Elevation (m)
P12-4 - Water Elevation (m)
P12-5 - Water Elevation (m)
P13-9 - Water Elevation (m)
P02-5 - Water Elevation (m)
P13-1 - Water Elevation (m)
P13-8 - Water Elevation (m)

VALLEY BUTTRESS BERM - LACUSTRINE

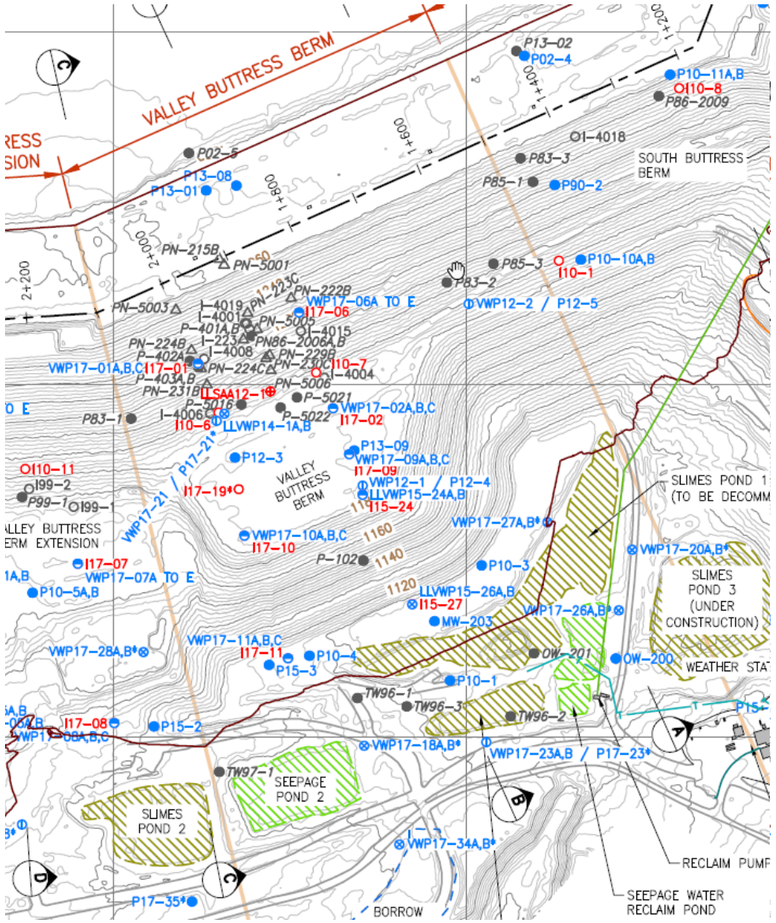

VALLEY BUTTRESS BERM
VALLEY BUTTRESS BERM EXTENSION
SOUTH BUTTRESS BERM
SLIMES POND 3 (UNDER CONSTRUCTION
SLIMES POND 2
SEEPAGE POND 2
SEEPAGE WATER RECLAIM POND
RECLAIM PU
BORROW
WEATHER S
P13-02
P02-4
P10-11A,B
I10-8
P86-2009
I-4018
P02-5
P13-08
P13-01
P83-3
P85-1
P90-2
PN-215B
PN-5001
P85-3
P10-10A,B
I10-1
P83-2
VWP12-2 / P12-5
PN-5003
VWP17-06A TO E
I17-06
PN-222B
PN-222C
I-4019
I-4001
P-401A,B
PN-5005
I-4015
PN-224B
P-402A,B
I-4008
PN86-2006A,B
PN-2296
VWP17-01A,B,C
I17-01
PN-224C
I10-7
I-4004
P-403A,B
PN-231B
PN-5006
LLSAA12-1
P-5016
P-5021
I-4006
I10-6
LLVWP14-1A,B
P-5022
VWP17-02A,B,C
I17-02
P83-1
P13-09
VWP17-09A,B,C
I17-09
P12-3
I10-11
I99-2
I99-1
I17-19
VWP17-21 / P17-21
VWP12-1 / P12-4
LLVWP15-24A,B
I15-24
P-102
VWP17-10A,B,C
I17-10
VWP17-27A,B
VWP17-20A,B
I17-07
VWP17-07A TO E
P10-5A,B
P10-3
LLVWP15-26A,B
I15-27
MW-203
VWP17-26A,B
VWP17-28A,B
VWP17-11A,B,C
I17-11
P15-3
P10-4
OW-201
OW-200
P10-1
TW96-1
TW96-3
TW96-2
I17-08
P15-2
VWP17-18A,B
VWP17-23A,B / P17-23
TW97-1
VWP17-34A,B
P17-35
1160
1140
1120

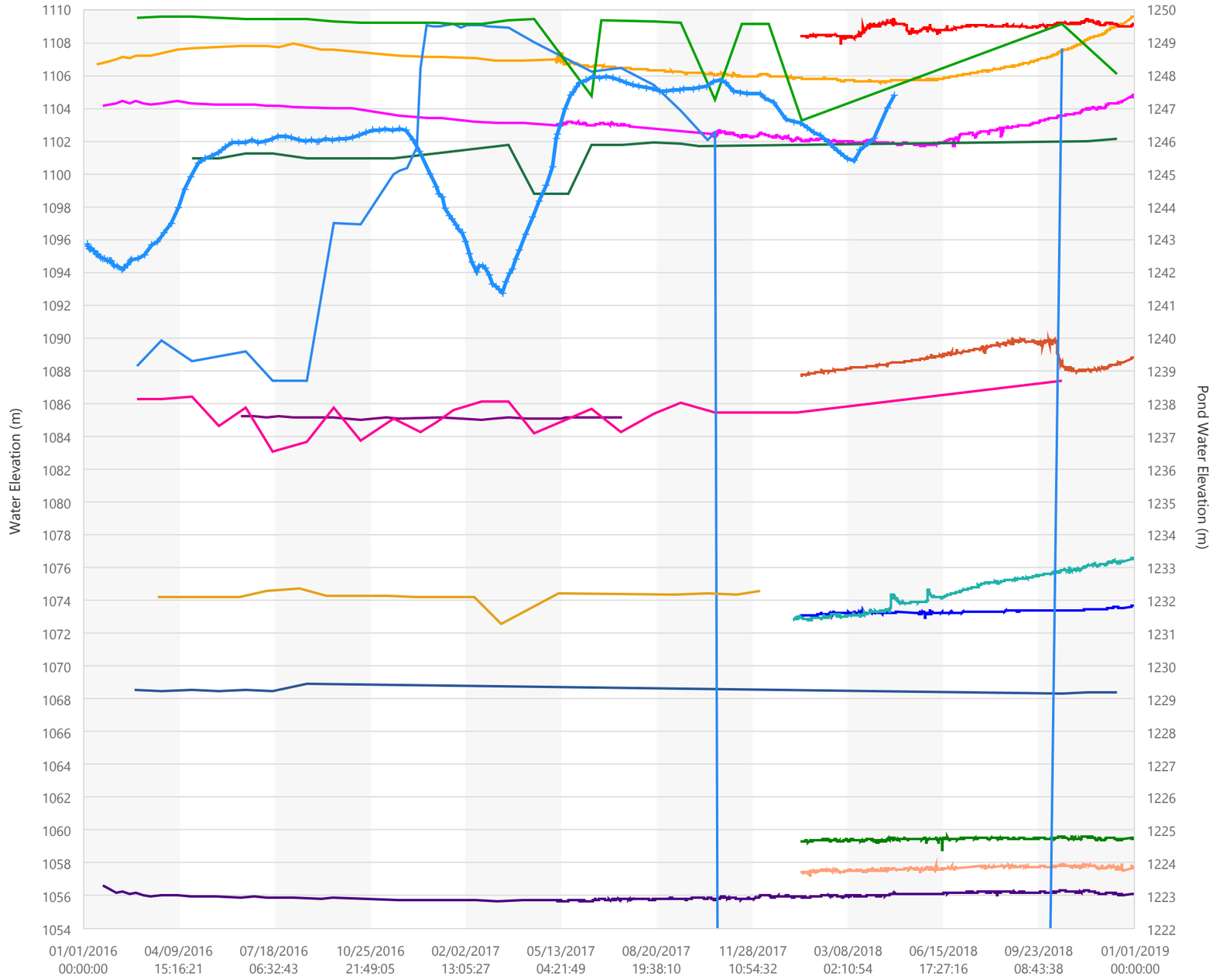

Water Elevation (m)
Pond Water Elevation (m)
1116
1115
1114
1113
1112
1111
1110
1109
1108
1107
1106
1105
1104
1103
1102
1101
1100
1099
1098
1250
1249
1248
1247
1246
1245
1244
1243
1242
1241
1240
1239
1238
1237
1236
1235
1234
1233
1232
01/01/2017 00:00:00
03/08/2017 08:43:38
05/13/2017 17:27:16
07/19/2017 02:10:54
09/23/2017 10:54:32
11/28/2017 19:38:10
02/03/2018 04:21:49
04/10/2018 13:05:27
06/15/2018 21:49:05
08/21/2018 06:32:43
10/26/2018 15:16:21
01/01/2019 00:00:00
LL-VWP17-01C (Lacustrine) - Water Elevation (m)
LL-VWP17-06D (Lucustrine) - Water Elevation (m)
LL-VWP17-20B (Lacustrine) - Water Elevation (m)
LL-PondLevel - Raw3 ()

VALLEY BUTTRESS BERM - GLACIOLACUSTRINE

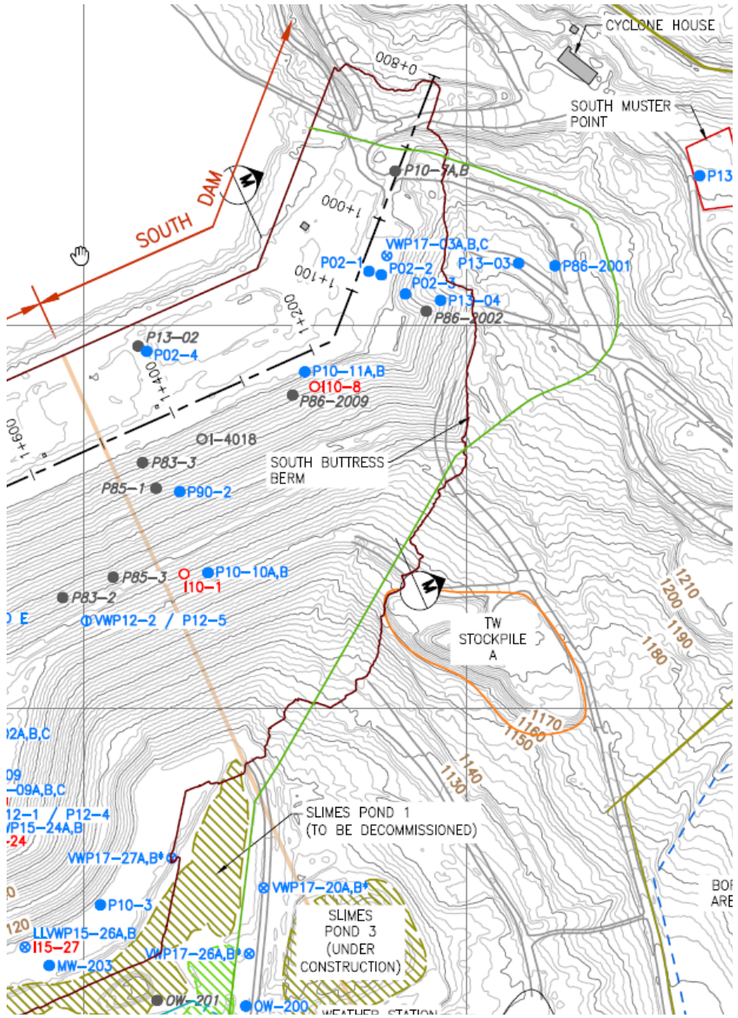

VALLEY BUTTRESS BERM
VALLEY BUTTRESS BERM EXTENSION
SLIMES POND 2
SEEPAGE POND 2
SOUTH BERM
BORROW
SEEPAGE RECLAIM
P13-02
P02-4
P02-5
P13-08
P13-01
P83-3
P85-1
P90-2
P85-3
P10-10A,B
I10-1
P83-2
VWP12-2 / P12-5
VWP17-06A TO E
I17-06
PN-5001
PN-5003
PN-5005
PN-5006
PN-5021
PN-5022
VWP17-01A,B,C
I17-01
I10-7
I10-6
LLVWP14-1A,B
VWP17-02A,B,C
I17-02
P12-3
P13-09
VWP17-09A,B,C
I17-09
VWP12-1 / P12-4
LLVWP15-24A,B
I15-24
I17-19
I10-11
I99-2
I99-1
P99-1
VWP17-10A,B,C
I17-10
P-102
VWP17-27A,B
P10-3
VWP17-07A TO E
I17-07
P10-5A,B
LLVWP15-26A,B
I15-27
VWP17-26A,B
MW-203
VWP17-11A,B,C
I17-11
P10-4
P15-3
OW-201
OW-200
P10-1
TW96-1
TW96-3
TW96-2
VWP17-18A,B
VWP17-23A,B / P17-23
TW97-1
I17-08
P15-2
VWP17-34A,B
P17-35
VWP17-28A,B
P17-21
VWP17-21
I15-11
I16-0
I16-1
I16-2
I16-3
I16-4
I16-5
I16-6
I16-7
I16-8
I16-9
I16-10
I16-11
I16-12
I16-13
I16-14
I16-15
I16-16
I16-17
I16-18
I16-19
I16-20
I16-21
I16-22
I16-23
I16-24
I16-25
I16-26
I16-27
I16-28
I16-29
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I16-37
I16-38
I16-39

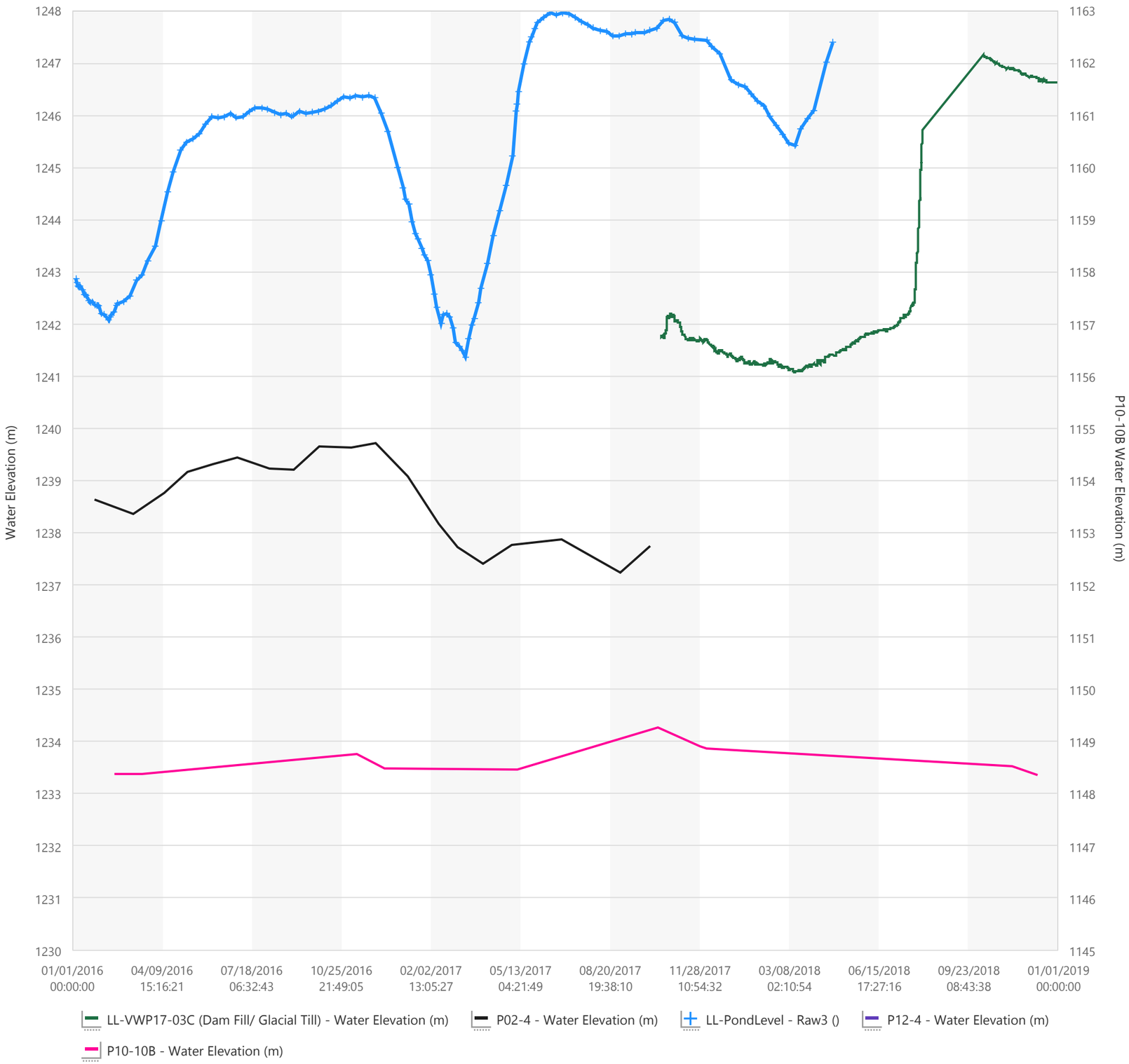
VALLEY BUTTRESS BERM - GLACIAL TILL, SAND AND GRAVEL


VALLEY BUTTRESS BERM
SOUTH BUTTRESS BERM
VALLEY BUTTRESS BERM
SLIMES POND 1 (TO BE DECOMM
SLIMES POND 3 (UNDER CONSTRUCTION)
WEATHER STA
SEEPAGE POND 2
SLIMES POND 2
RECLAIM PUMP
SEEPAGE WATER RECLAIM POND
BORROW
P13-02
P02-4
P10-11A,B
I10-8
P86-2009
I-4018
P02-5
P13-08
P13-01
P83-3
P85-1
P90-2
P85-3
P10-10A,B
I10-1
P83-2
VWP12-2 / P12-5
VWP17-06A TO E
I17-06
I-4019
I-4001
I-4015
I-4004
I-4008
I-4006
P-5016
P-5021
P-5022
P-5006
P83-1
I10-6
LLSAA12-1
LLVWP14-1A,B
VWP17-02A,B,C
I17-02
P13-09
VWP17-09A,B,C
I17-09
VWP12-1 / P12-4
LLVWP15-24A,B
I15-24
P12-3
I17-19
I10-11
P99-2
P99-1
I99-2
I99-1
VWP17-21 / P17-21
VWP17-10A,B,C
I17-10
P-102
VWP17-27A,B
VWP17-20A,B
I17-07
VWP17-07A TO E
P10-5A,B
P10-3
LLVWP15-26A,B
I15-27
VWP17-26A,B
MW-203
VWP17-28A,B
VWP17-11A,B,C
I17-11
P10-4
P15-3
OW-201
OW-200
P10-1
TW96-1
TW96-3
TW96-2
P15-2
I17-08
VWP17-18A,B
VWP17-23A,B / P17-23
TW97-1
VWP17-34A,B
P17-35
PN-215B
PN-5001
PN-222B
PN-5003
PN-5004
PN-224B
PN86-2006A,B
PN-224C
PN-5005
PN-2298
PN-2318
VWP17-01A,B,C
I17-01
P-403A,B
P-4024
P-401A,B
I-4008
I-2234
I-4001
I-4019
1+200
1+400
1+600
1+800
2+000
2+200

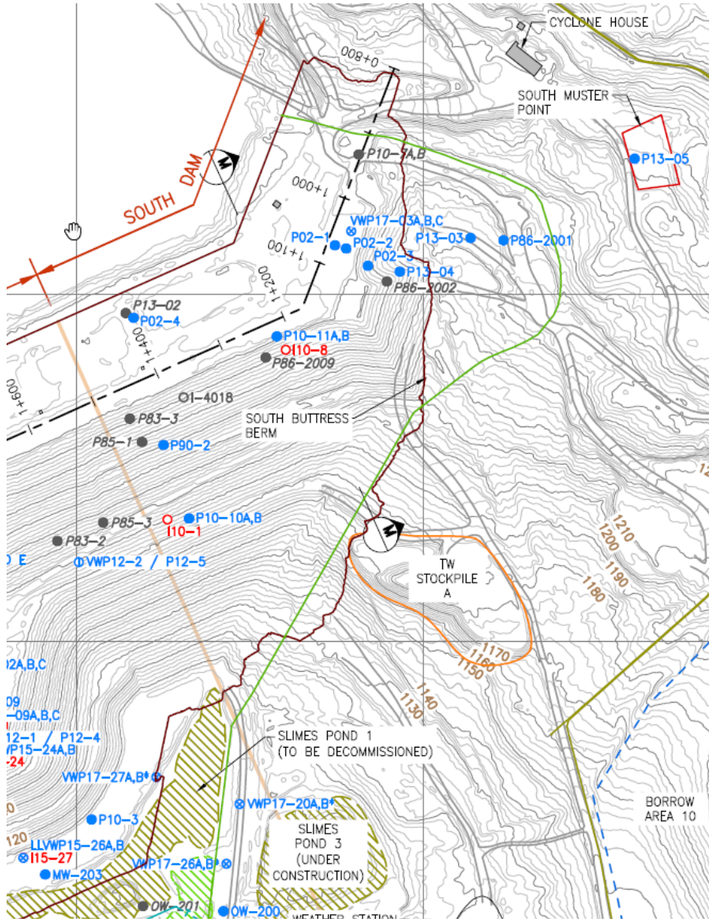

Water Elevation (m)
Pond Water Elevation (m)
1110
1108
1106
1104
1102
1100
1098
1096
1094
1092
1090
1088
1086
1084
1082
1080
1078
1076
1074
1072
1070
1068
1066
1064
1062
1060
1058
1056
1054
1250
1249
1248
1247
1246
1245
1244
1243
1242
1241
1240
1239
1238
1237
1236
1235
1234
1233
1232
1231
1230
1229
1228
1227
1226
1225
1224
1223
1222
01/01/2016 00:00:00
04/09/2016 15:16:21
07/18/2016 06:32:43
10/25/2016 21:49:05
02/02/2017 13:05:27
05/13/2017 04:21:49
08/20/2017 19:38:10
11/28/2017 10:54:32
03/08/2018 02:10:54
06/15/2018 17:27:16
09/23/2018 08:43:38
01/01/2019 00:00:00
LL-VWP12-01 (Glacial Till) - Water Elevation (m)
LL-VWP12-02 - Water Elevation (m)
LL-VWP14-01A (Glacial Till) - Water Elevation (m)
LL-VWP15-24A (Sand and Gravel Lower) - Water Elevation (m)
LL-VWP17-01A (Lower Sand and Gravel) - Water Elevation (m)
LL-VWP17-11A (Lower Sand and Gravel) - Water Elevation (m)
LL-VWP17-11C (Glacial Till) - Water Elevation (m)
LL-VWP17-02A (Lower Sand and Gravel) - Water Elevation (m)
LL-VWP17-09A (Lower S&G) - Water Elevation (m)
LL-VWP17-09C (Glacial Till) - Water Elevation (m)
P10-01 - Water Elevation (m)
P-102 - Water Elevation (m)
P10-03 - Water Elevation (m)
P10-04 - Water Elevation (m)
P12-3 - Water Elevation (m)
P15-3 - Water Elevation (m)
LL-PondLevel - Raw3 ()

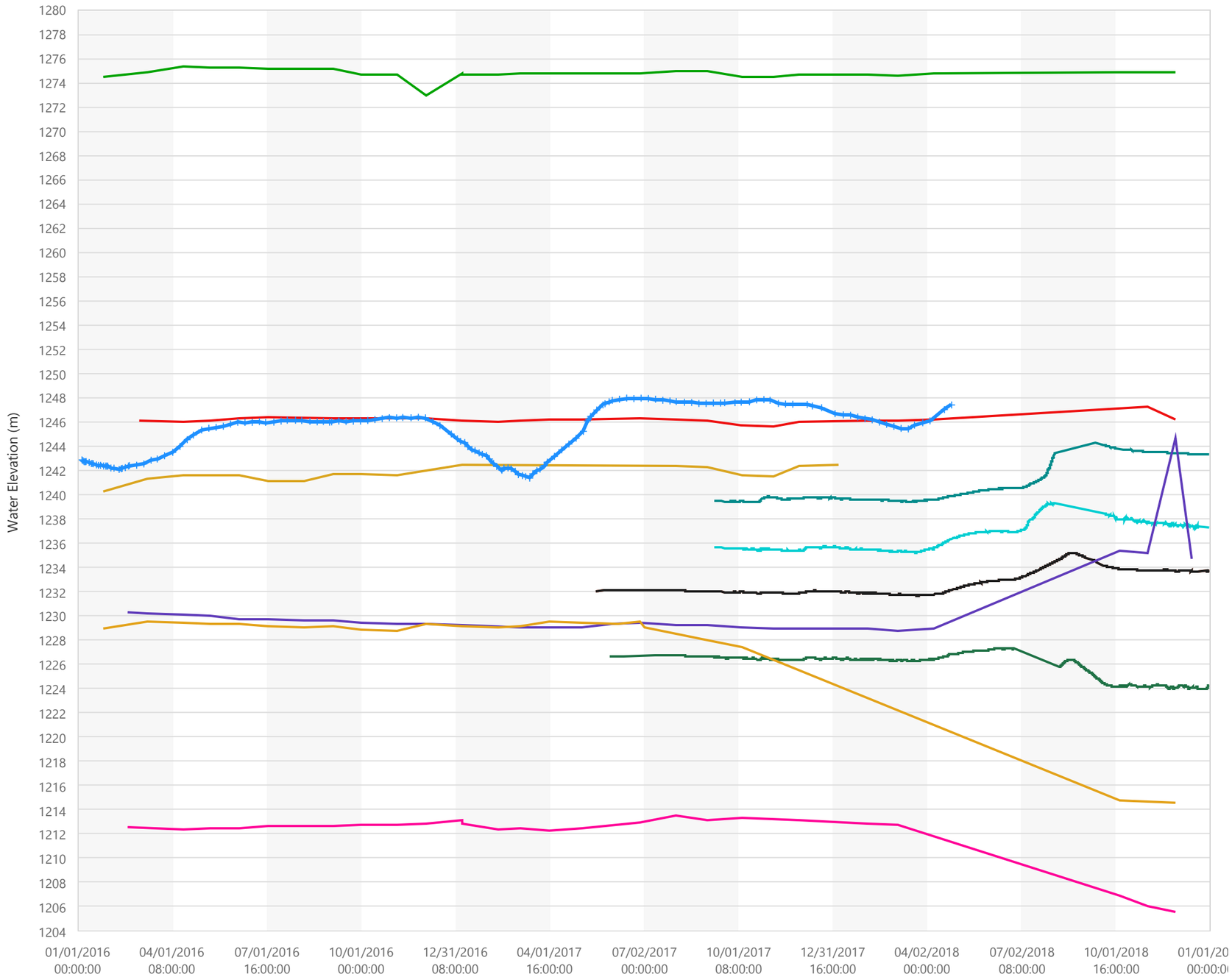
SOUTH DAM - DAM FILL


CYCLONE HOUSE
SOUTH MUSTER POINT
SOUTH DAM
P10-7A,B
P13
VWP17-03A,B,C
P02-1
P02-2
P13-03
P86-2001
P02-3
P13-04
P86-2002
P13-02
P02-4
P10-11A,B
OI10-8
P86-2009
OI-4018
SOUTH BUTTRESS BERM
P83-3
P85-1
P90-2
P85-3
P10-10A,B
I10-1
P83-2
VWP12-2 / P12-5
TW STOCKPILE A
SLIMES POND 1 (TO BE DECOMMISSIONED)
VWP17-27A,B
VWP17-20A,B
P10-3
LLVWP15-26A,B
I15-27
MW-203
VWP17-26A,B
SLIMES POND 3 (UNDER CONSTRUCTION)
OW-201
OW-200
0+800
1+000
1+100
1+200
1+400
1+600
1210
1200
1190
1180
1170
1160
1150
1140
1130

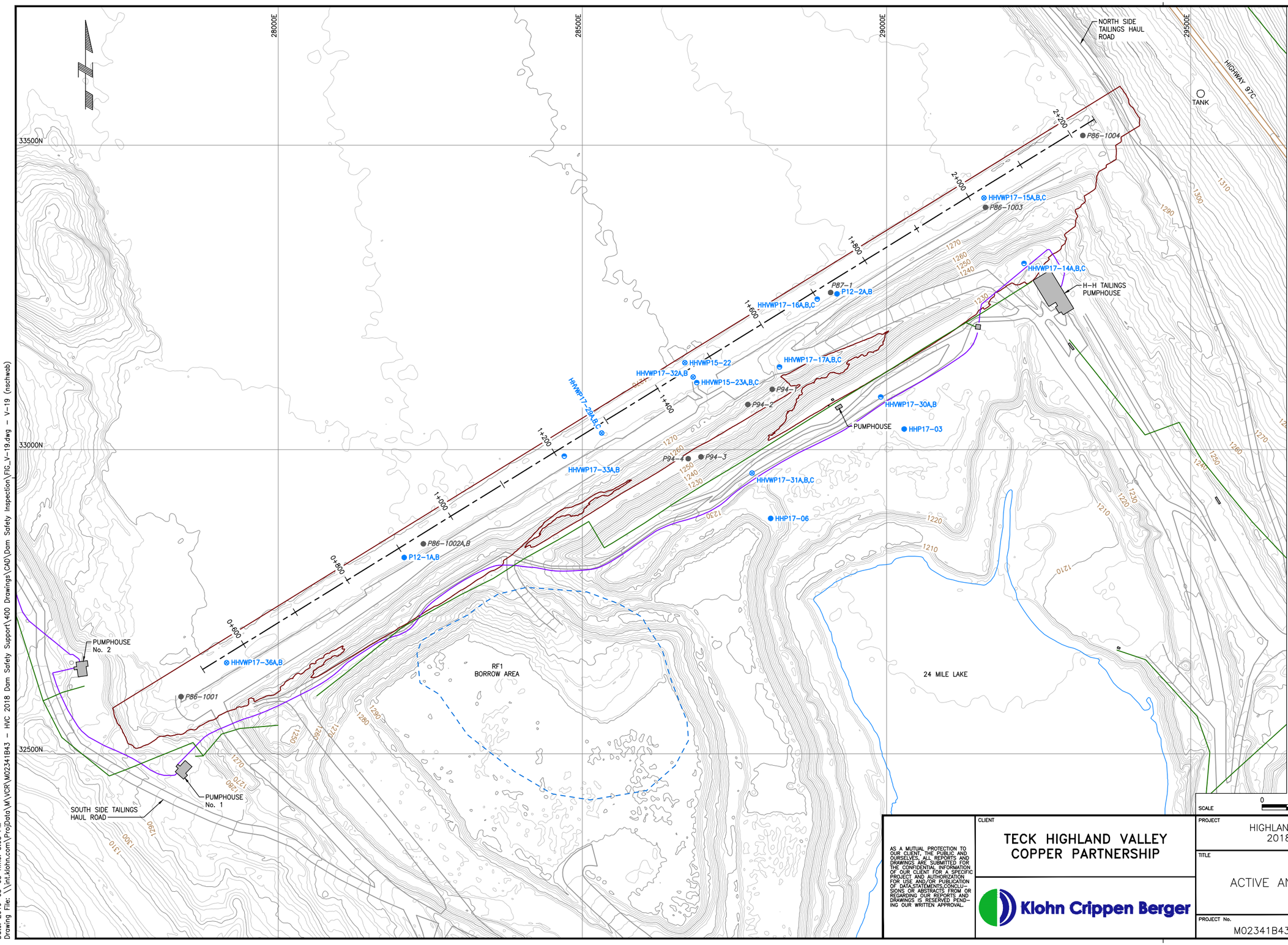

Water Elevation (m)
P10-10B Water Elevation (m)
1248
1247
1246
1245
1244
1243
1242
1241
1240
1239
1238
1237
1236
1235
1234
1233
1232
1231
1230
1163
1162
1161
1160
1159
1158
1157
1156
1155
1154
1153
1152
1151
1150
1149
1148
1147
1146
1145
01/01/2016 00:00:00
04/09/2016 15:16:21
07/18/2016 06:32:43
10/25/2016 21:49:05
02/02/2017 13:05:27
05/13/2017 04:21:49
08/20/2017 19:38:10
11/28/2017 10:54:32
03/08/2018 02:10:54
06/15/2018 17:27:16
09/23/2018 08:43:38
01/01/2019 00:00:00
LL-VWP17-03C (Dam Fill/ Glacial Till) - Water Elevation (m)
P02-4 - Water Elevation (m)
LL-PondLevel - Raw3 ()
P12-4 - Water Elevation (m)
P10-10B - Water Elevation (m)

SOUTH DAM - GRANODIORITE FOUNDATION ROCK AND GLACIAL TILL


CYCLONE HOUSE
SOUTH MUSTER POINT
SOUTH DAM
P10–7A,B
P13–05
VWP17–03A,B,C
P02–1
P02–2
P02–3
P13–03
P86–2001
P13–04
P86–2002
P13–02
P02–4
P10–11A,B
OI10–8
P86–2009
OI–4018
SOUTH BUTTRESS BERM
P83–3
P85–1
P90–2
P85–3
P10–10A,B
I10–1
P83–2
VWP12–2 / P12–5
TW STOCKPILE A
SLIMES POND 1 (TO BE DECOMMISSIONED)
VWP17–27A,B
P10–3
VWP17–20A,B
BORROW AREA 10
LLVWP15–26A,B
I15–27
MW–203
VWP17–26A,B
SLIMES POND 3 (UNDER CONSTRUCTION)
OW–201
OW–200
WEATHER STATION


Water Elevation (m)
1280
1278
1276
1274
1272
1270
1268
1266
1264
1262
1260
1258
1256
1254
1252
1250
1248
1246
1244
1242
1240
1238
1236
1234
1232
1230
1228
1226
1224
1222
1220
1218
1216
1214
1212
1210
1208
1206
1204
01/01/2016 00:00:00
04/01/2016 08:00:00
07/01/2016 16:00:00
10/01/2016 00:00:00
12/31/2016 08:00:00
04/01/2017 16:00:00
07/02/2017 00:00:00
10/01/2017 08:00:00
12/31/2017 16:00:00
04/02/2018 00:00:00
07/02/2018 08:00:00
10/01/2018 16:00:00
01/01/20 00:00:0
P13-3 - Raw3 ()
LL-VWP17-03B (Glacial Till) - Water Elevation (m)
LL-VWP17-03A (Granodirite) - Water Elevation (m)
LL-VWP02-01 (Glacial Till - In Granodirite Trench) - Water Elevation (m)
LL-VWP02-03 (Glacial Till - In Granodirite Trench) - Water Elevation (m)
LL-VWP02-01 (Glacial Till - In Granodirite Trench) - Water Elevation (m)
P02-2 - Water Elevation (m)
P10-11A - Water Elevation (m)
P13-4 - Water Elevation (m)
P13-5 - Water Elevation (m)
P86-2001 - Water Elevation (m)
LL-PondLevel - Raw3 ()

H-H DAM ACTIVE AND DEFUNCT PIEZOMETERS LOCATION PLAN



LEGEND:

- BORROW AREA
- ULTIMATE DAM FOOTPRINT
- TAILINGS PIPELINE
- POWERLINE
- HAUL ROAD
- PUBLIC ROAD
- L-L DAM CENTERLINE (0+800)

ACTIVE INSTRUMENTS (SEE NOTE 2):

- STANDPIPE PIEZOMETER AND OBSERVATION WELL
- VIBRATING-WIRE PIEZOMETER
- COMBINED INCLINOMETER AND VIBRATING-WIRE PIEZOMETER

DEFUNCT INSTRUMENTS (SEE NOTE 3):

- DEFUNCT STANDPIPE PIEZOMETER

NOTES:

1. TOPOGRAPHY PROVIDED BY TECK HIGHLAND VALLEY COPPER PARTNERSHIP AND WAS DERIVED FROM SATELLITE IMAGERY TAKEN ON 2018-10-06 AND 2016-09-25 & 28.
2. ACTIVE INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: CURRENTLY READING AN ACTIVE WATER LEVEL, DRY OR PLUGGED <20 m ABOVE TIP ELEVATION AS THIS COULD SHOW A RESPONSE IN THE FUTURE.
3. DEFUNCT INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: DESTROYED, DAMAGED OR PLUGGED >20 m ABOVE TIP ELEVATION.

SCALE 0 200 m

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA,STATEMENTS,CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

TITLE
H-H DAM
ACTIVE AND DEFUNCT PIEZOMETERS
LOCATION PLAN

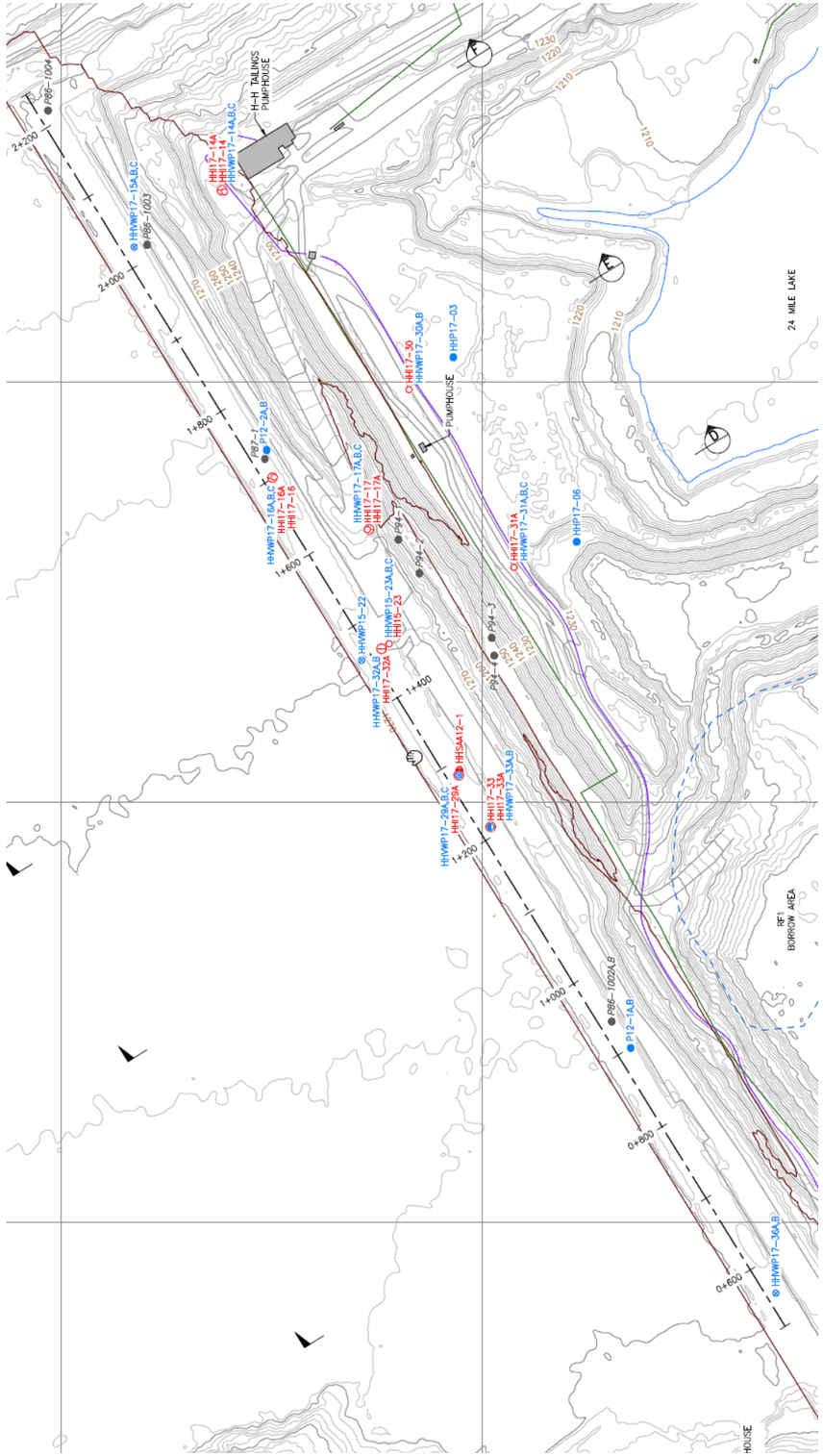
PROJECT No. M02341B43

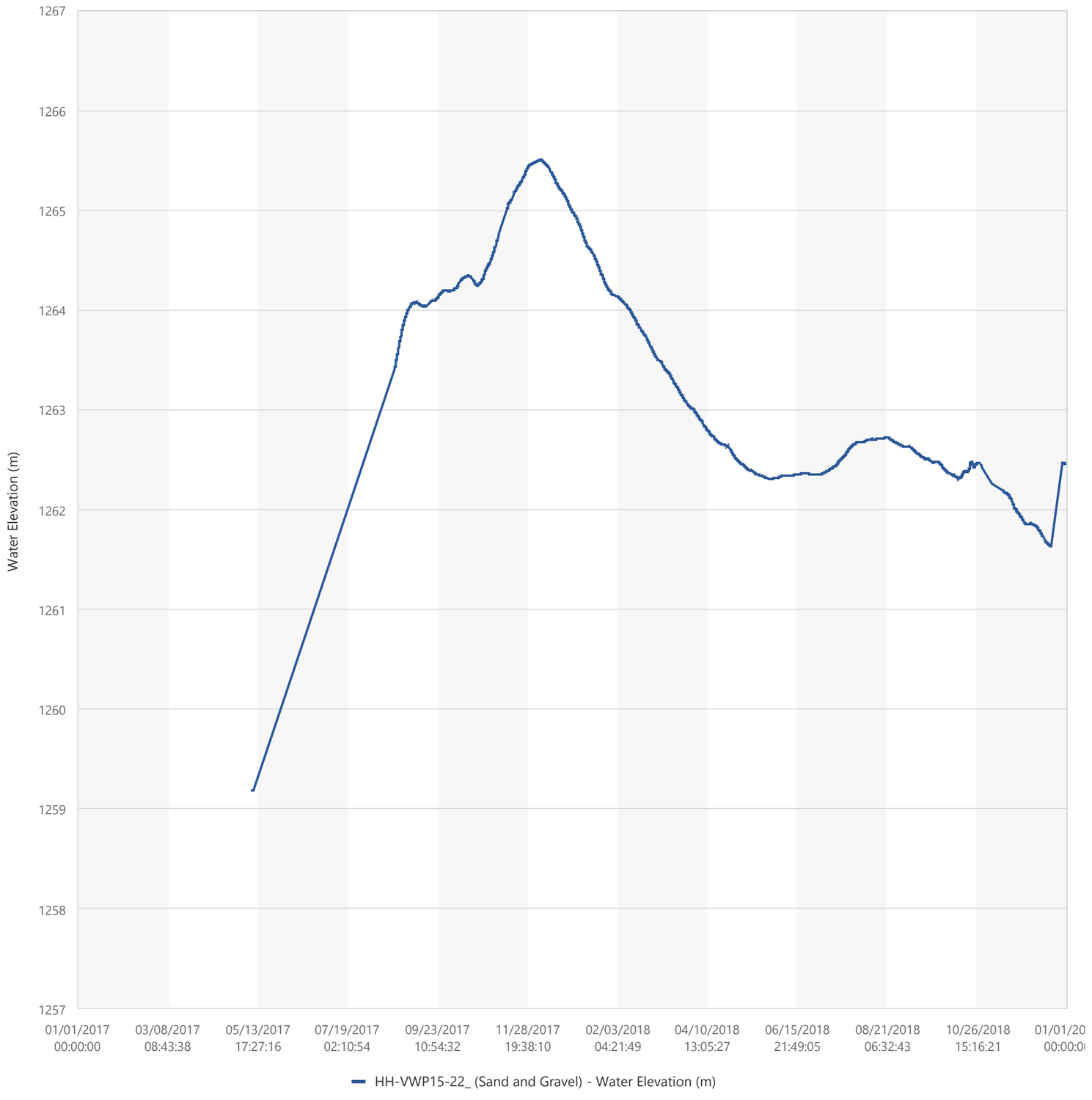
FIG. No. V-19

KCB-R-MLD

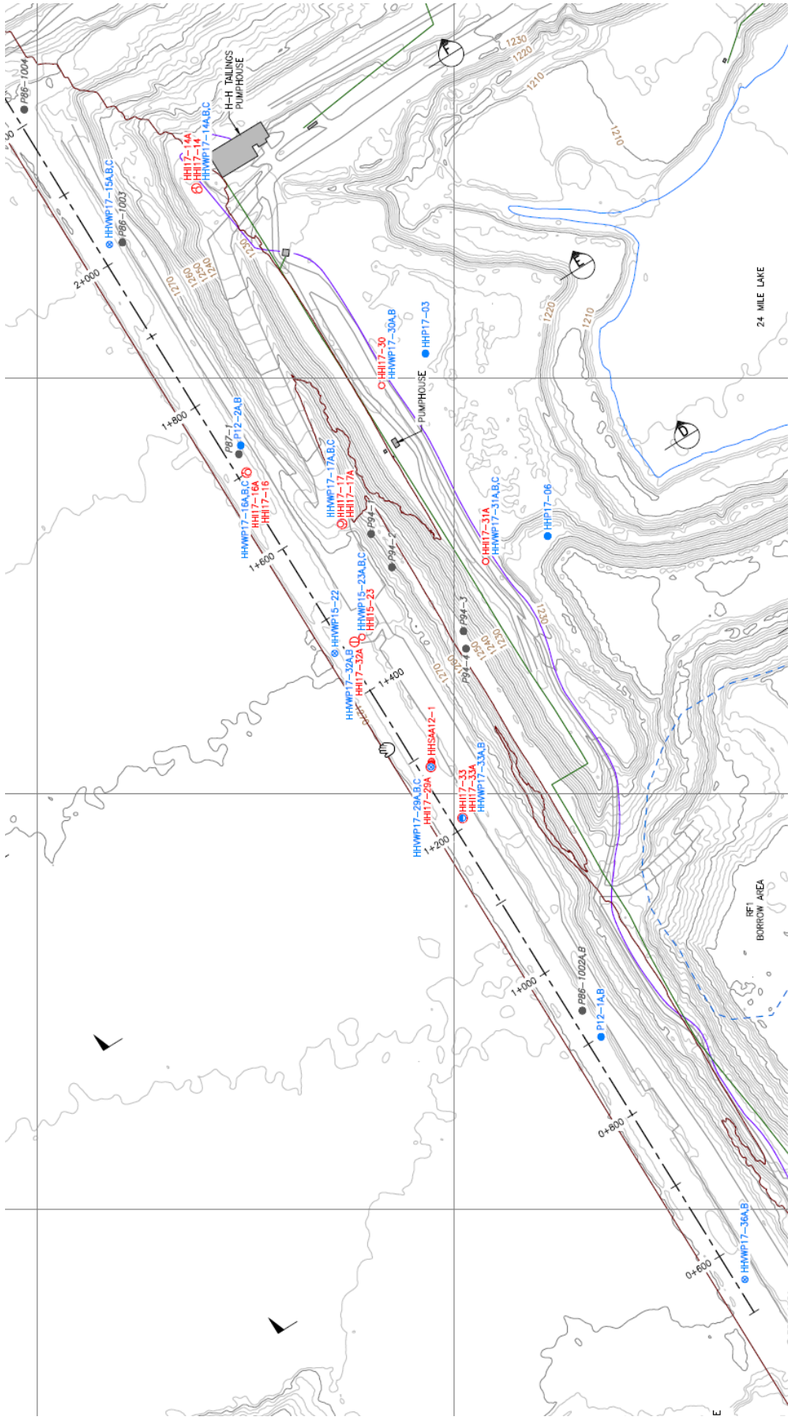
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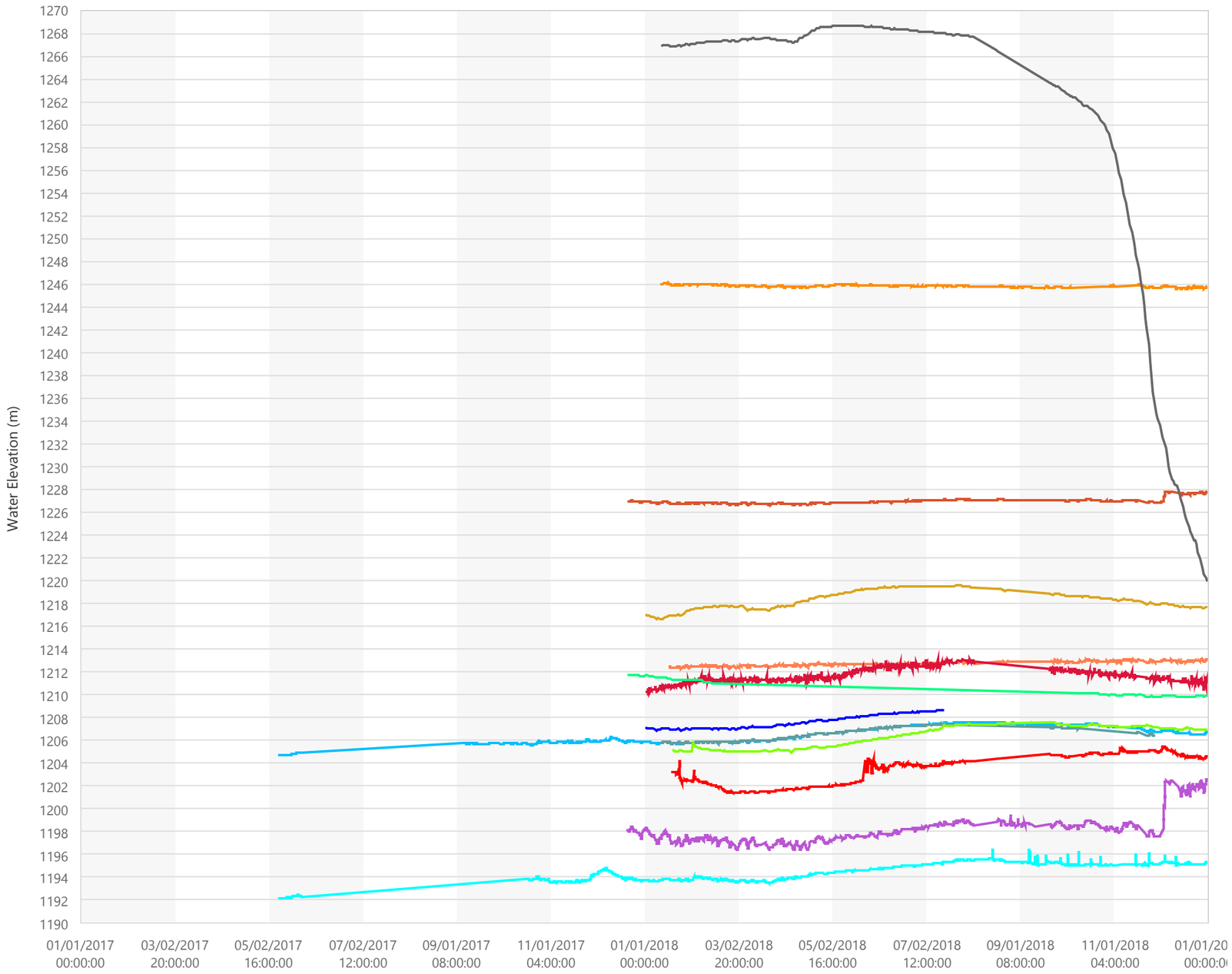
H-H DAM - UPSTREAM OF CORE


H-H TAILINGS PUMPHOUSE
24 MILE LAKE
PUMPHOUSE
RF1 BORROW AREA
HOUSE
HHWP17-15A,B,C
HHWP17-14A,B,C
HHWP17-30A,B
HHWP17-31A,B,C
HHWP17-17A,B,C
HHWP17-16A,B,C
HHWP15-22
HHWP15-23A,B,C
HHWP17-32A,B
HHWP17-29A,B,C
HHWP17-33A,B
HHWP17-36A,B
HHP17-03
HHP17-06
P12-2A,B
P12-1A,B
P86-1004
P86-1003
P86-1002A,B
P87-1
P94-1
P94-2
P94-3
HHS412-1
HH17-14A
HH17-14
HH17-30
HH17-31A
HH17-16A
HH17-16
HH17-17A
HH15-23
HH17-32A
HH17-29A
HH17-33
HH17-36
2+200
2+000
1+800
1+600
1+400
1+200
1+000
0+800
0+600
1230
1220
1210
1270
1260
1240

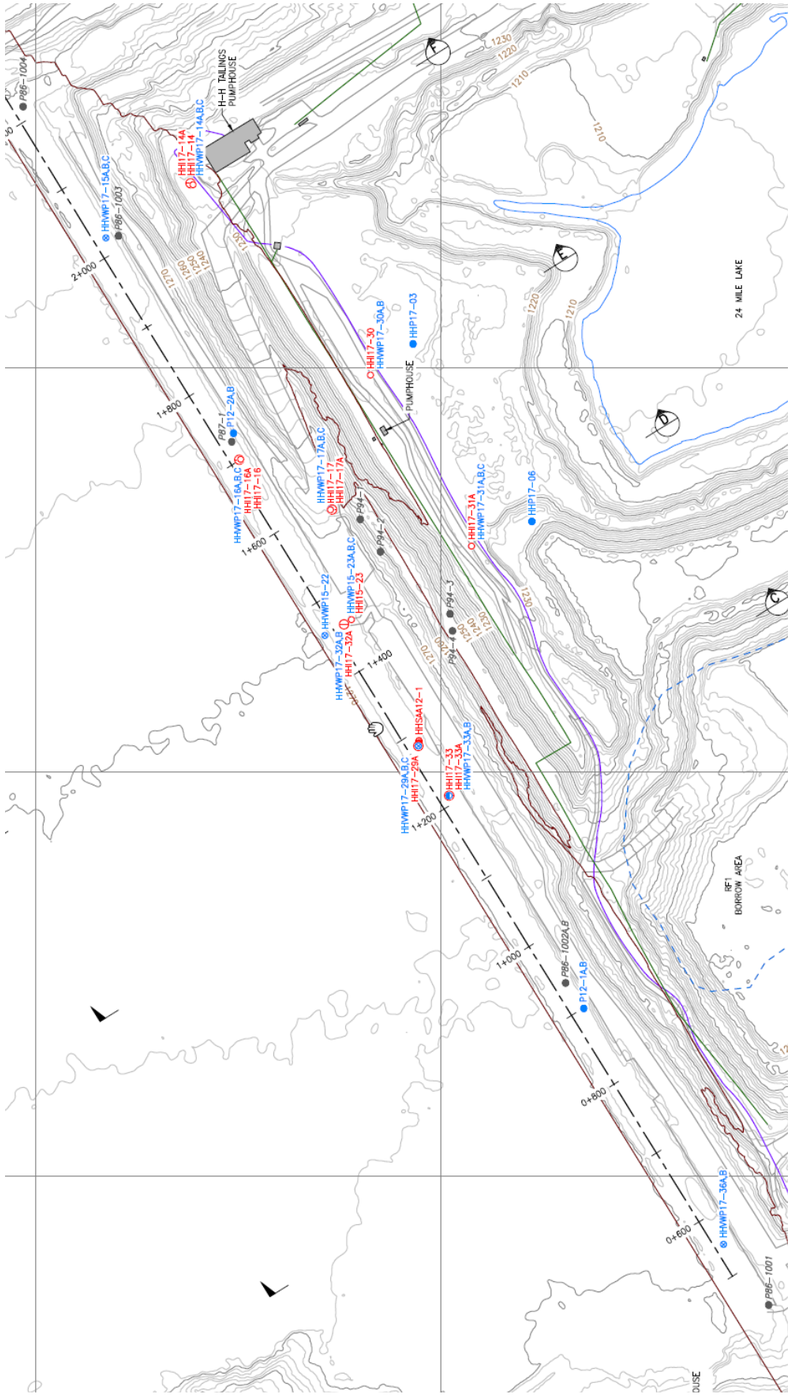

Water Elevation (m)
1267
1266
1265
1264
1263
1262
1261
1260
1259
1258
1257
01/01/2017 00:00:00
03/08/2017 08:43:38
05/13/2017 17:27:16
07/19/2017 02:10:54
09/23/2017 10:54:32
11/28/2017 19:38:10
02/03/2018 04:21:49
04/10/2018 13:05:27
06/15/2018 21:49:05
08/21/2018 06:32:43
10/26/2018 15:16:21
01/01/20 00:00:0
HH-VWP15-22_ (Sand and Gravel) - Water Elevation (m)

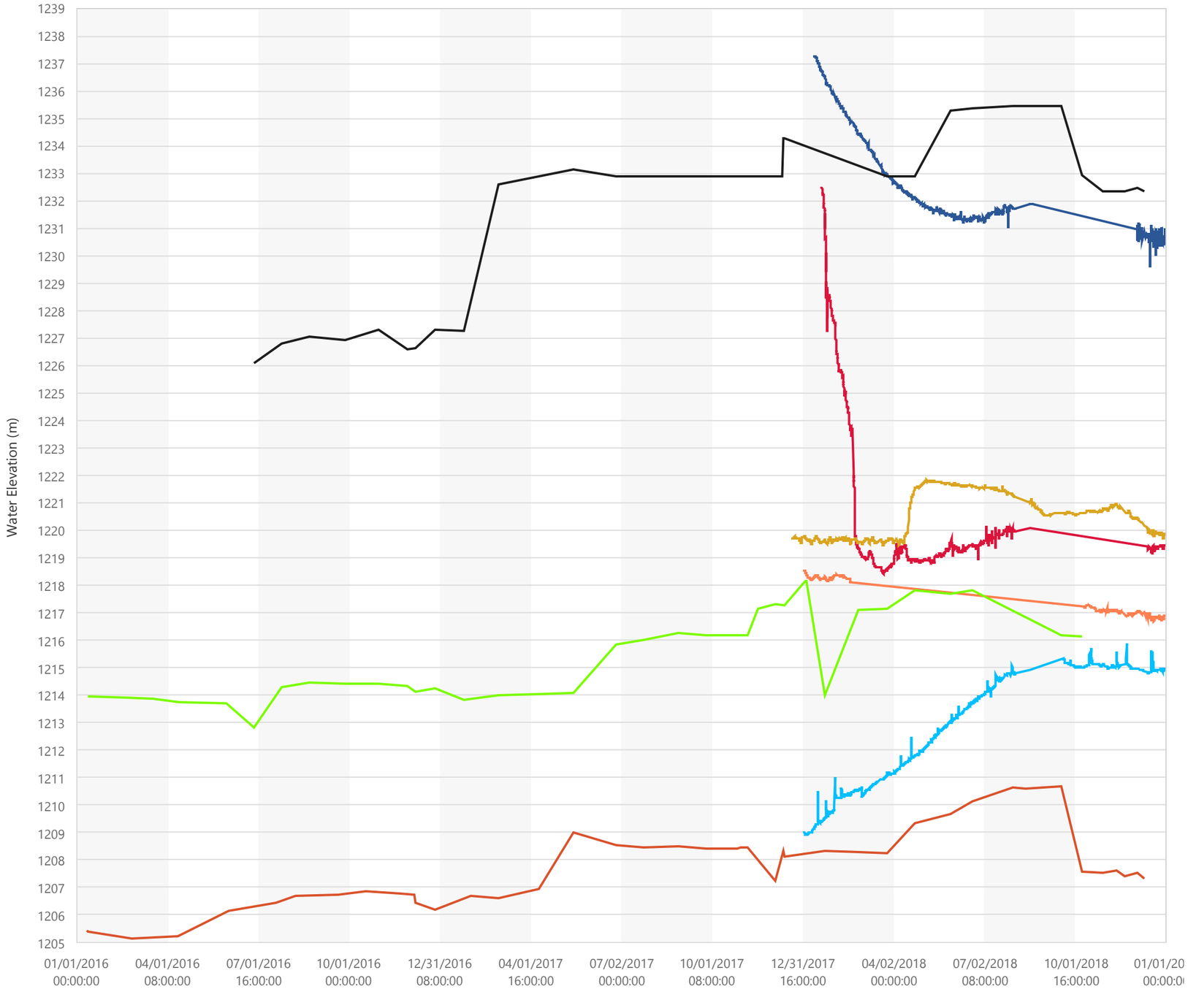
H-H DAM - DAM FILL, SAND AND GRAVEL


H-H TAILINGS PUMPHOUSE
24 MILE LAKE
PUMPHOUSE
ISPT BORROW AREA
HHWP17-14A,B,C
HHWP17-15A,B,C
HHWP17-17A,B,C
HHWP17-30A,B
HHWP17-31A,B,C
HHWP17-32A,B
HHWP17-33A,B
HHWP17-34A,B
HHWP15-22
HHWP15-23A,B,C
HHWP17-29A,B,C
HHP17-03
HHP17-06
P12-2A,B
P12-1A,B
HH17-14A
HH17-14
HH17-15A
HH17-16
HH17-17A
HH17-30
HH17-31A
HH17-32A
HH15-23
HH17-33
HH17-33A
HH17-29A
HH5A12-1
P94-1
P94-2
P94-3
P86-1003
P86-1004
P86-1002A,B
1+800
1+600
1+400
1+200
1+000
0+800
0+600
1230
1220
1210
1240
1250

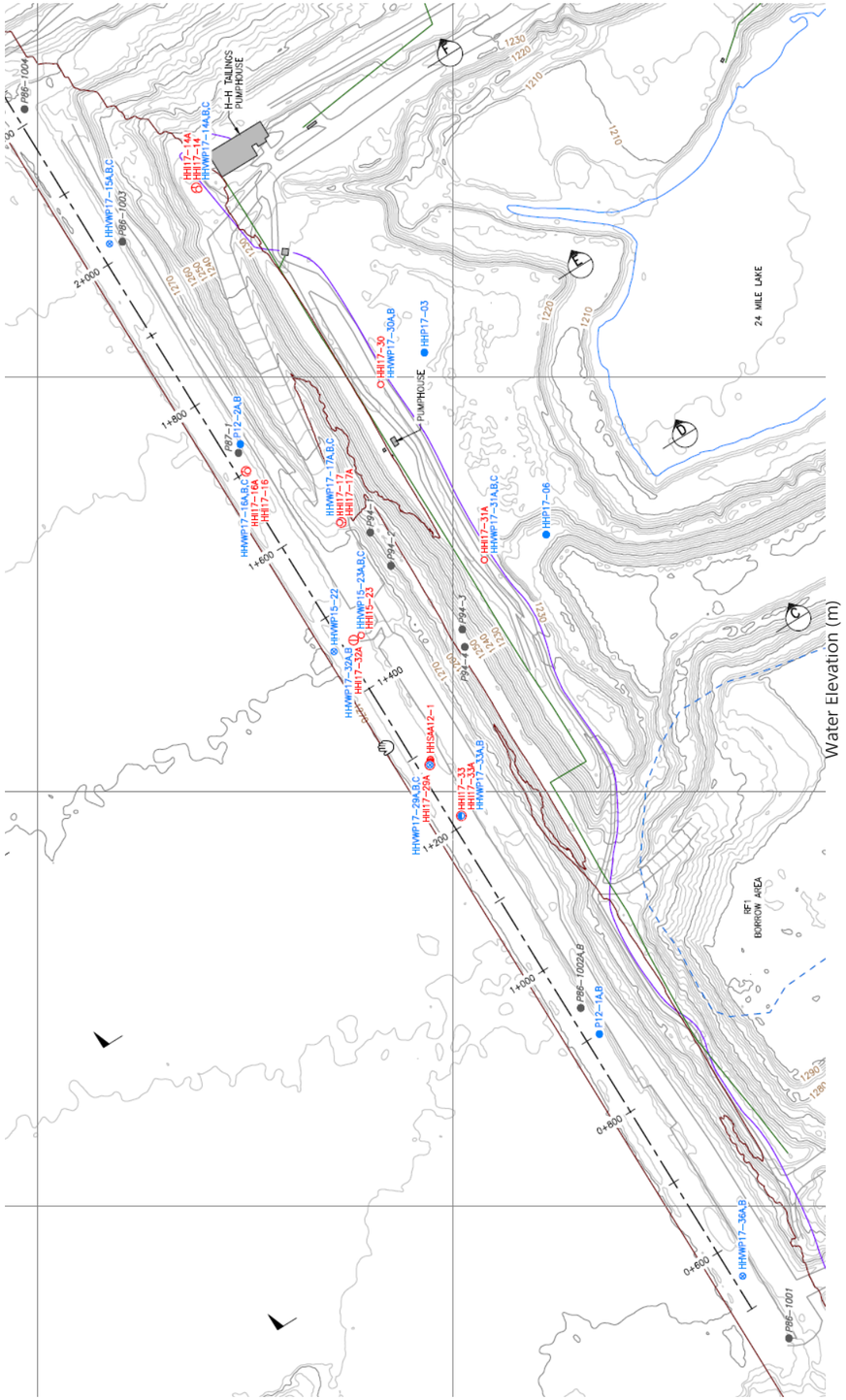

Water Elevation (m)
1270
1268
1266
1264
1262
1260
1258
1256
1254
1252
1250
1248
1246
1244
1242
1240
1238
1236
1234
1232
1230
1228
1226
1224
1222
1220
1218
1216
1214
1212
1210
1208
1206
1204
1202
1200
1198
1196
1194
1192
1190
01/01/2017 00:00:00
03/02/2017 20:00:00
05/02/2017 16:00:00
07/02/2017 12:00:00
09/01/2017 08:00:00
11/01/2017 04:00:00
01/01/2018 00:00:00
03/02/2018 20:00:00
05/02/2018 16:00:00
07/02/2018 12:00:00
09/01/2018 08:00:00
11/01/2018 04:00:00
01/01/20 00:00:0
HH-VWP17-14C (Rock Fill) - Water Elevation (m)
HH-VWP17-16C (Rock Fill) - Water Elevation (m)
HH-VWP17-17B (Upper Sand and Gravel) - Water Elevation (m)
HH-VWP17-30A (Silty Sand and Gravel) - Water Elevation (m)
HH-VWP17-36B (Glacial Till) - Water Elevation (m)
HH-VWP15-23C (Granular Fill) - Water Elevation (m)
HH-VWP17-16B (Upper Sand and Gravel) - Water Elevation (m)
HH-VWP17-17C (Rock Fill) - Water Elevation (m)
HH-VWP17-29A (Silty Sand and Gravel) - Water Elevation (m)
HH-VWP17-31C (Dam Fill - Sand and Gravel) - Water Elevation (m)
HH-VWP17-29B (Silty Sand and Gravel) - Water Elevation (m)
HH-VWP17-32B (Dam Fill -Sand and Gravel) - Water Elevation (m)
HH-VWP15-23A (Glacial Till) - Water Elevation (m)
HH-VWP17-15C (Rock fill/ Glacial Till Contact) - Water Elevation (m)

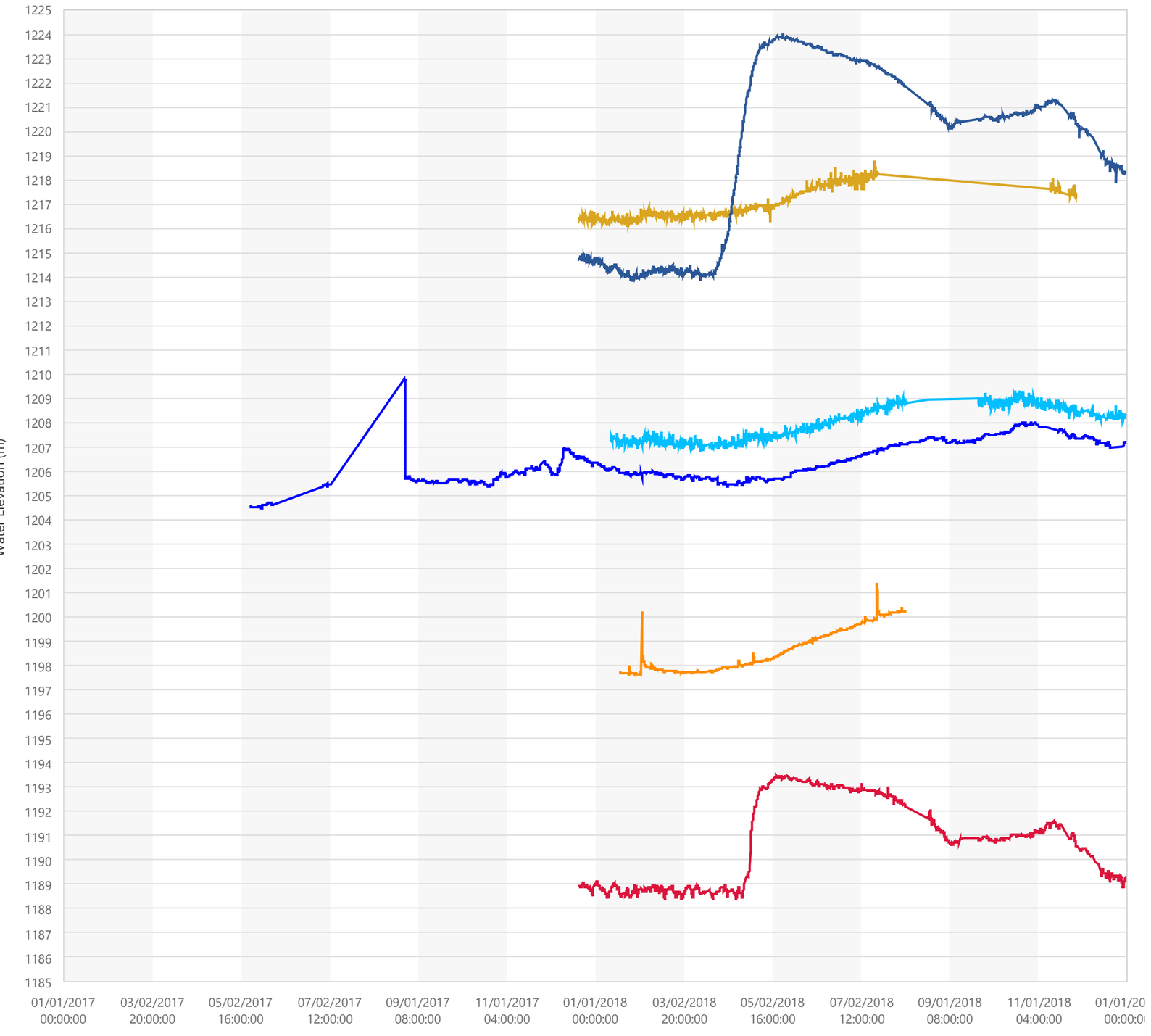
H-H DAM - GLACIAL TILL AND CLAYSILT


H-H TAILINGS PUMPHOUSE
24 MILE LAKE
PUMPHOUSE
RF1 BORROW AREA
HHWP17-15A,B,C
HHWP17-14A,B,C
HHWP17-17A,B,C
HHWP17-16A,B,C
HHWP17-29A,B,C
HHWP17-30A,B
HHWP17-31A,B,C
HHWP17-33A,B
HHWP17-32A,B
HHWP15-22
HHWP15-23A,B,C
HHWP17-38A,B
P86-1003
P87-1
P12-2A,B
P94-1
P86-1002A,B
P12-1A,B
P86-1001
HHPI17-03
HHPI17-06
HHSA12-1
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1+600
1+400
1+200
1+000
0+800
0+600
1210
1220
1230
1240

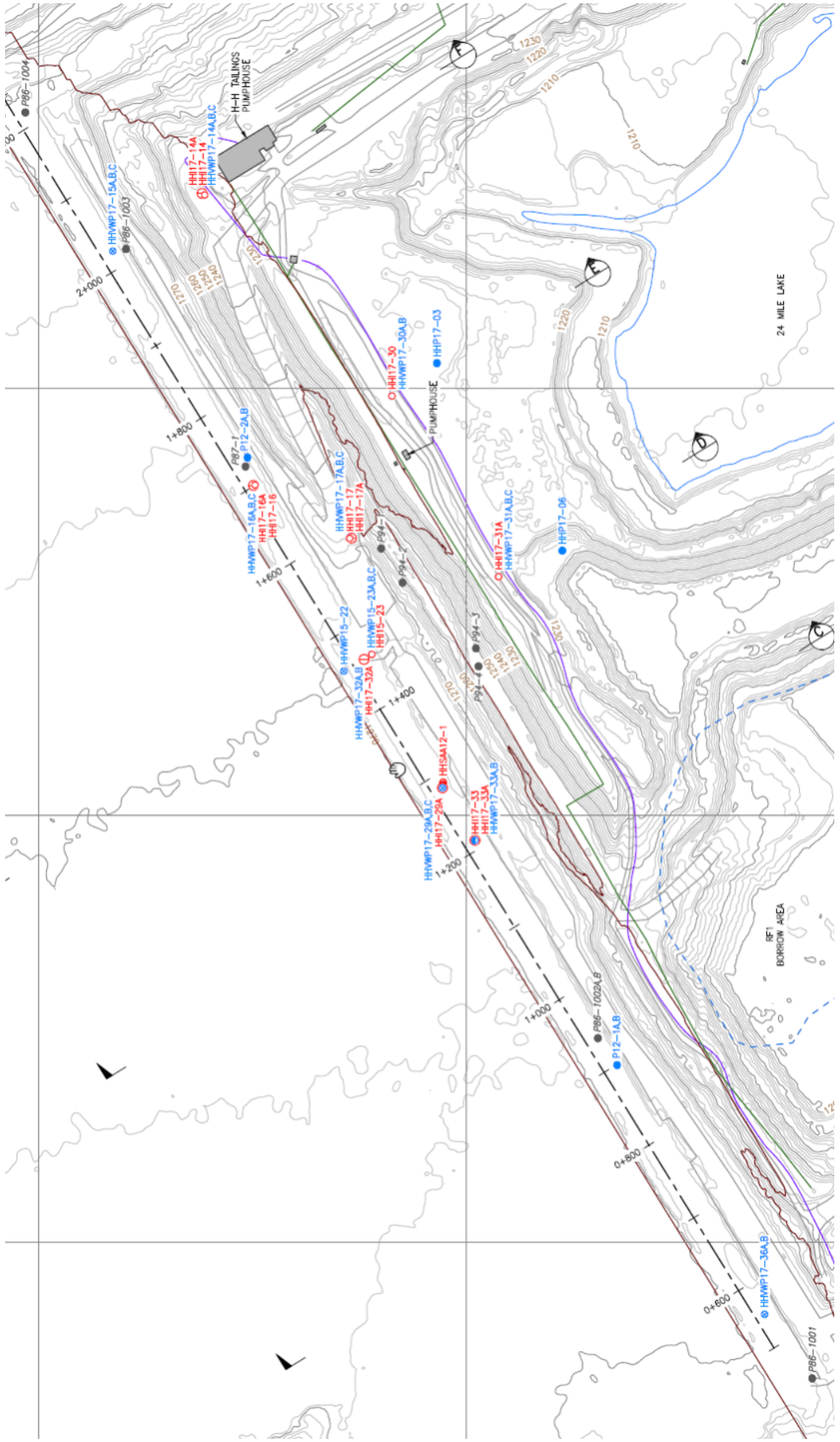

Water Elevation (m)
1239
1238
1237
1236
1235
1234
1233
1232
1231
1230
1229
1228
1227
1226
1225
1224
1223
1222
1221
1220
1219
1218
1217
1216
1215
1214
1213
1212
1211
1210
1209
1208
1207
1206
1205
01/01/2016 00:00:00
04/01/2016 08:00:00
07/01/2016 16:00:00
10/01/2016 00:00:00
12/31/2016 08:00:00
04/01/2017 16:00:00
07/02/2017 00:00:00
10/01/2017 08:00:00
12/31/2017 16:00:00
04/02/2018 00:00:00
07/02/2018 08:00:00
10/01/2018 16:00:00
Date
HH-VWP17-15B (Glacial Till) - Water Elevation (m)
HH-VWP17-29C (Glacial Till) - Water Elevation (m)
HH-VWP17-30B (Glacial Till) - Water Elevation (m)
HH-VWP17-14B (Glacial Till) - Water Elevation (m)
HH-VWP17-33B (Upper Sand and Gravel) - Water Elevation (m)
HH-P12-2B - Raw3 ()
HH-P12-1B - Water Elevation (m)
P86-1002A - Water Elevation (m)

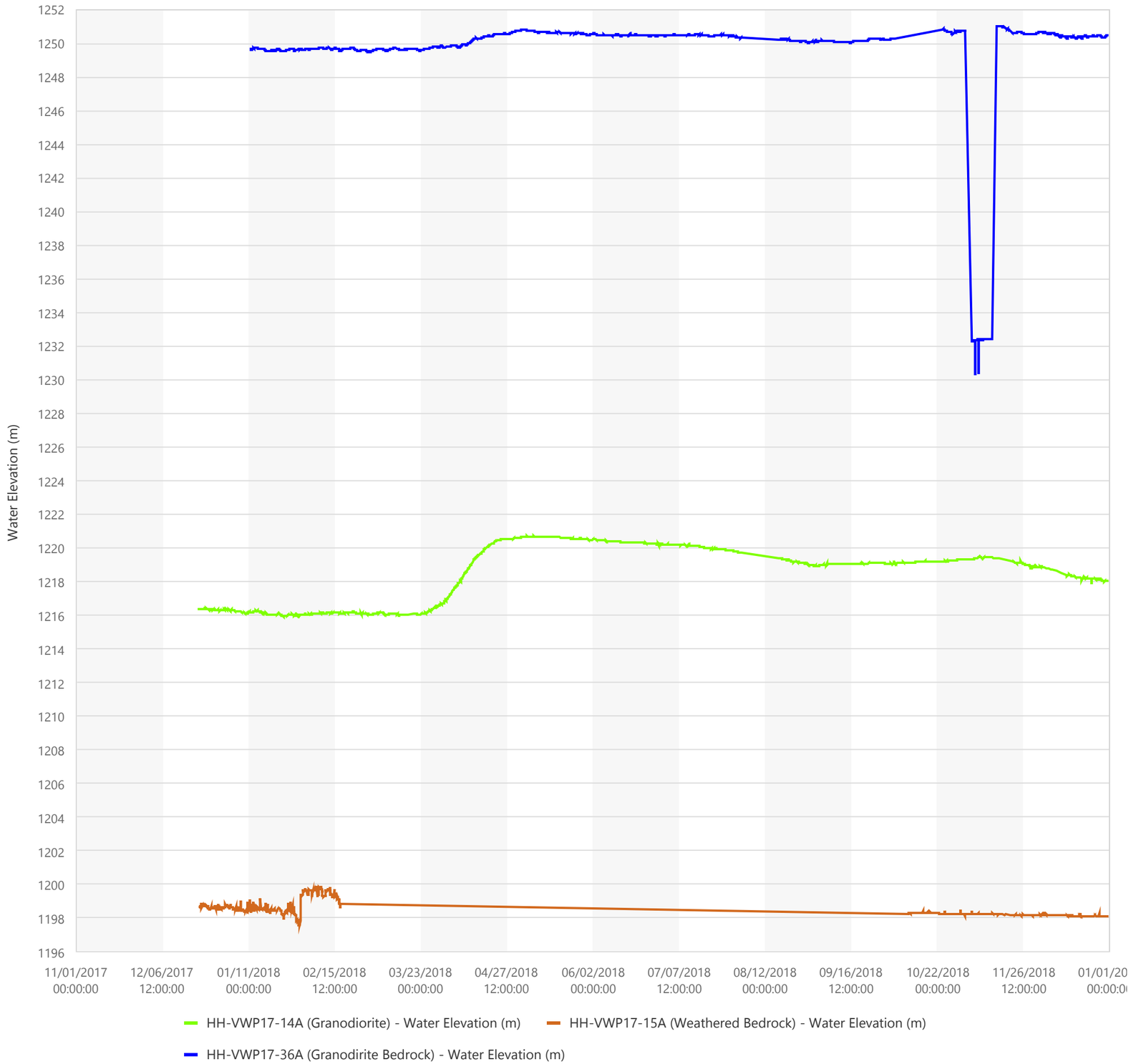
H-H DAM- GLACIOLACUSTRINE


H-H TAILINGS PUMPHOUSE
24 MILE LAKE
PUMPHOUSE
RF1 BORROW AREA
HH17-14A
HHWP17-14A,B,C
HHWP17-15A,B,C
P86-1004
P86-1003
HHWP17-32A,B
HH17-32A
HHWP15-22
HH17-16A
HHWP17-16A,B,C
HH17-16
P87-1
P12-2A,B
HHWP17-17A,B,C
HH17-17
HH17-17A
P94
P94-1
HH17-31A
HHWP17-31A,B,C
HHP17-06
HHP17-03
HH17-30
HHWP17-30A,B
HHWP15-23A,B,C
HHWP15-23
P94-2
HHSA12-1
HHWP17-29A,B,C
HH17-29A
HH17-33
HH17-33A
HHWP17-33A,B
P86-1002A,B
P12-1A,B
HHWP17-36A,B
P86-1001
1+800
1+600
1+400
1+200
1+000
0+800
0+600
1230
1220
1210
1240
1250
1260
1270
1280
1290
1300


Water Elevation (m)
1225
1224
1223
1222
1221
1220
1219
1218
1217
1216
1215
1214
1213
1212
1211
1210
1209
1208
1207
1206
1205
1204
1203
1202
1201
1200
1199
1198
1197
1196
1195
1194
1193
1192
1191
1190
1189
1188
1187
1186
1185
01/01/2017 00:00:00
03/02/2017 20:00:00
05/02/2017 16:00:00
07/02/2017 12:00:00
09/01/2017 08:00:00
11/01/2017 04:00:00
01/01/2018 00:00:00
03/02/2018 20:00:00
05/02/2018 16:00:00
07/02/2018 12:00:00
09/01/2018 08:00:00
11/01/2018 04:00:00
01/01/20 00:00:0
HH-VWP15-23B (Glaciolacustrine) - Water Elevation (m)
HH-VWP17-31B (Clay Layer 1) - Water Elevation (m)
HH-VWP17-16A (Silt/Clay Layer) - Water Elevation (m)
HH-VWP17-32A (Clay Layer 2) - Water Elevation (m)
HH-VWP17-17A (Silt/Clay Layer) - Water Elevation (m)
HH-VWP17-31A (Clay Layer 2) - Water Elevation (m)

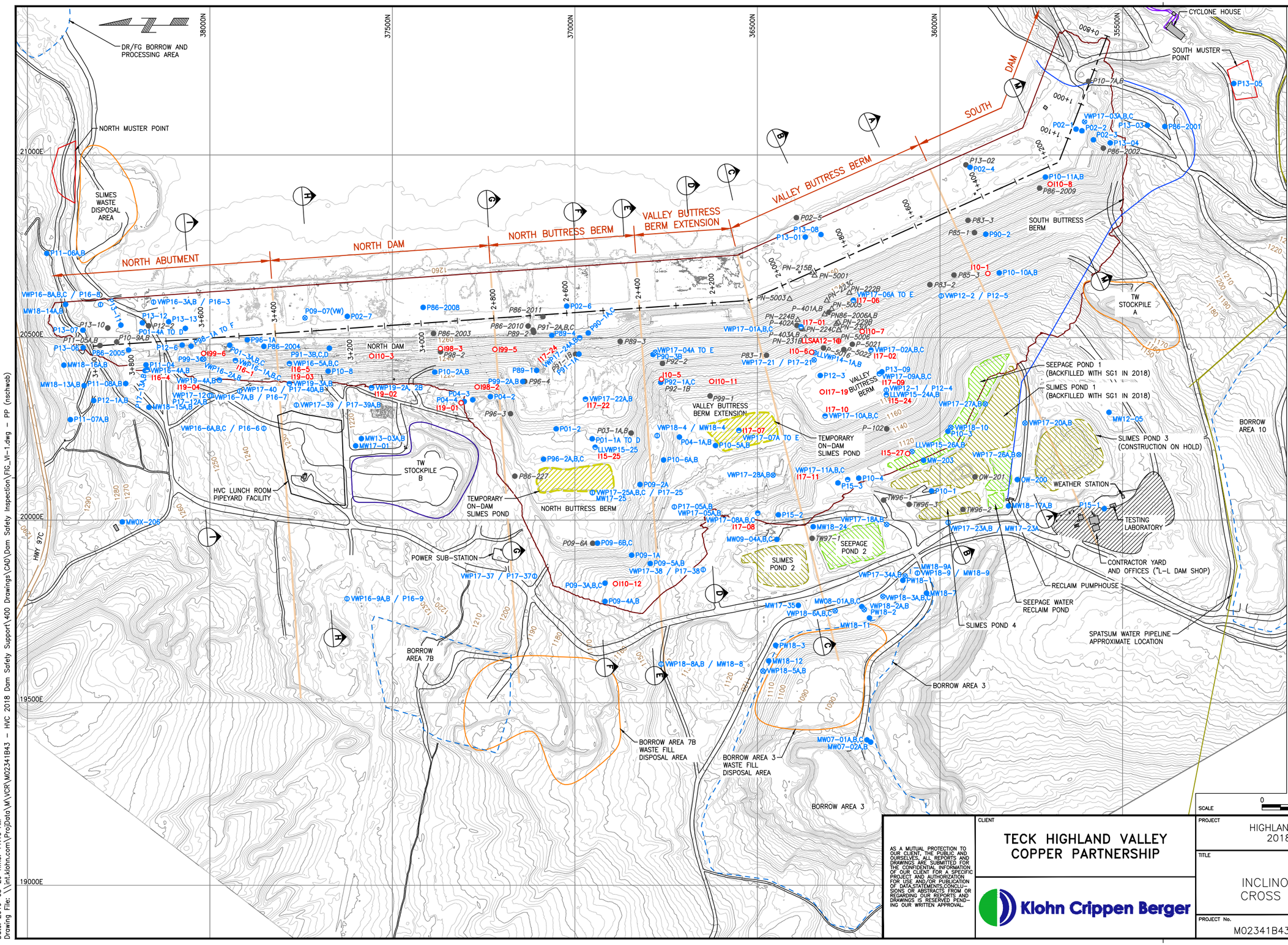
H-H DAM- FOUNDATION ROCK


H-H TAILINGS PUMPHOUSE
24 MILE LAKE
PUMPHOUSE
RF1 BORROW AREA
HH17-14A
HHVWP17-14A,B,C
HHVWP17-15A,B,C
HH17-30
HHVWP17-30A,B
HHP17-03
HHP17-06
HH17-31A
HHVWP17-31A,B,C
HHVWP17-17A,B,C
HH17-17
HH17-17A
HH17-16
HHVWP17-16A,B,C
HH17-16A
HHVWP15-22
HHVWP15-23A,B,C
HH15-22
HHVWP17-32A,B
HH17-32A
HH5A12-1
HHVWP17-29A,B,C
HH17-29A
HH17-33
HH17-33A
HHVWP17-33A,B
HHVWP17-36A,B
P12-22A,B
P12-1A,B
P86-1004
P86-1003
P86-1002A,B
P86-1001
P87-1
P94-1
P94-2
P94-3
1+800
1+600
1+400
1+200
1+000
0+800
0+600
1230
1220
1210
1240
1250
1260
1270


Water Elevation (m)
1252
1250
1248
1246
1244
1242
1240
1238
1236
1234
1232
1230
1228
1226
1224
1222
1220
1218
1216
1214
1212
1210
1208
1206
1204
1202
1200
1198
1196
11/01/2017 00:00:00
12/06/2017 12:00:00
01/11/2018 00:00:00
02/15/2018 12:00:00
03/23/2018 00:00:00
04/27/2018 12:00:00
06/02/2018 00:00:00
07/07/2018 12:00:00
08/12/2018 00:00:00
09/16/2018 12:00:00
10/22/2018 00:00:00
11/26/2018 12:00:00
01/01/20 00:00:0
HH-VWP17-14A (Granodiorite) - Water Elevation (m)
HH-VWP17-15A (Weathered Bedrock) - Water Elevation (m)
HH-VWP17-36A (Granodirite Bedrock) - Water Elevation (m)

APPENDIX VI

Inclinometer and Piezometer Cross Sections



LEGEND:

- BORROW AREA
- WASTE FILL DISPOSAL AREA
- SEEPAGE POND
- SLIMES POND
- SLIMES POND (ON-DAM)
- EL. 1279 m ULTIMATE DAM FOOTPRINT
- SURFACE WATER RECLAIM PIPELINE
- SPATSUM WATER PIPELINE
- HAUL ROAD
- PUBLIC ROAD
- L-L DAM CENTERLINE (0+800)
- GEOLOGICAL CROSS SECTION

ACTIVE INSTRUMENTS (SEE NOTE 2):

- STANDPIPE PIEZOMETER AND OBSERVATION WELL
- VIBRATING-WIRE PIEZOMETER
- COMBINED STANDPIPE PIEZOMETER AND VIBRATING-WIRE PIEZOMETER
- COMBINED INCLINOMETER AND VIBRATING-WIRE PIEZOMETER
- STANDARD INCLINOMETER
- IN-PLACE SAA INCLINOMETER

DEFUNCT INSTRUMENTS (SEE NOTE 3):

- DEFUNCT PNEUMATIC PIEZOMETER
- DEFUNCT STANDPIPE PIEZOMETER
- DEFUNCT INCLINOMETER

NOTES:

3. TOPOGRAPHY OF L-L DAM IS GENERALLY BASED ON THE FOLLOWING:
   - AREAS OUTSIDE THE DAM FOOTPRINT ARE BASED ON OCTOBER 2018 PHOTOSAT SURVEY.
   - AREAS OF HYDRAULICALLY PLACED FILLS ARE BASED ON AS-BUILT SURVEYS PROVIDED BY TECK HIGHLAND VALLEY COPPER DATED 2018-12-10 (II-HS-3), 2018-11-14 (I-HS-1), 2018-10-22 (I-HS-2), 2018-12-05 (VBBE) AND 2018-12-17 (I-HS-4).
   - AREAS OF MECHANICALLY PLACED FILLS (SG1, S1 AND S2) AND FOUNDATION EXCAVATIONS (I-E-1, I-E-2, I-A-1, I-A-2, II-E-1, II-E-2, II-E-3) ARE GENERALLY BASED ON AS-BUILT SURVEYS PROVIDED BY NORTH AMERICAN CONSTRUCTION GROUP, DATED 2019-02-06 (COMPILED L-L APPROVED FOUNDATIONS), 2019-02-14 (COMPILED L-L S1 BLANKET), AND 2019-02-13 (COMPILED SG1 BLANKET).
4. ACTIVE INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: CURRENTLY READING AN ACTIVE WATER LEVEL, DRY OR PLUGGED <20 m ABOVE TIP ELEVATION AS THIS COULD SHOW A RESPONSE IN THE FUTURE.
5. DEFUNCT INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: DESTROYED, DAMAGED OR PLUGGED >20 m ABOVE TIP ELEVATION.
6. ASTERISK (*) DENOTES PROPOSED INSTRUMENT LOCATION TO BE UPDATED WITH AS-CONSTRUCTED LOCATION WHEN SURVEY IS COMPLETED.

SCALE 0 250 m

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

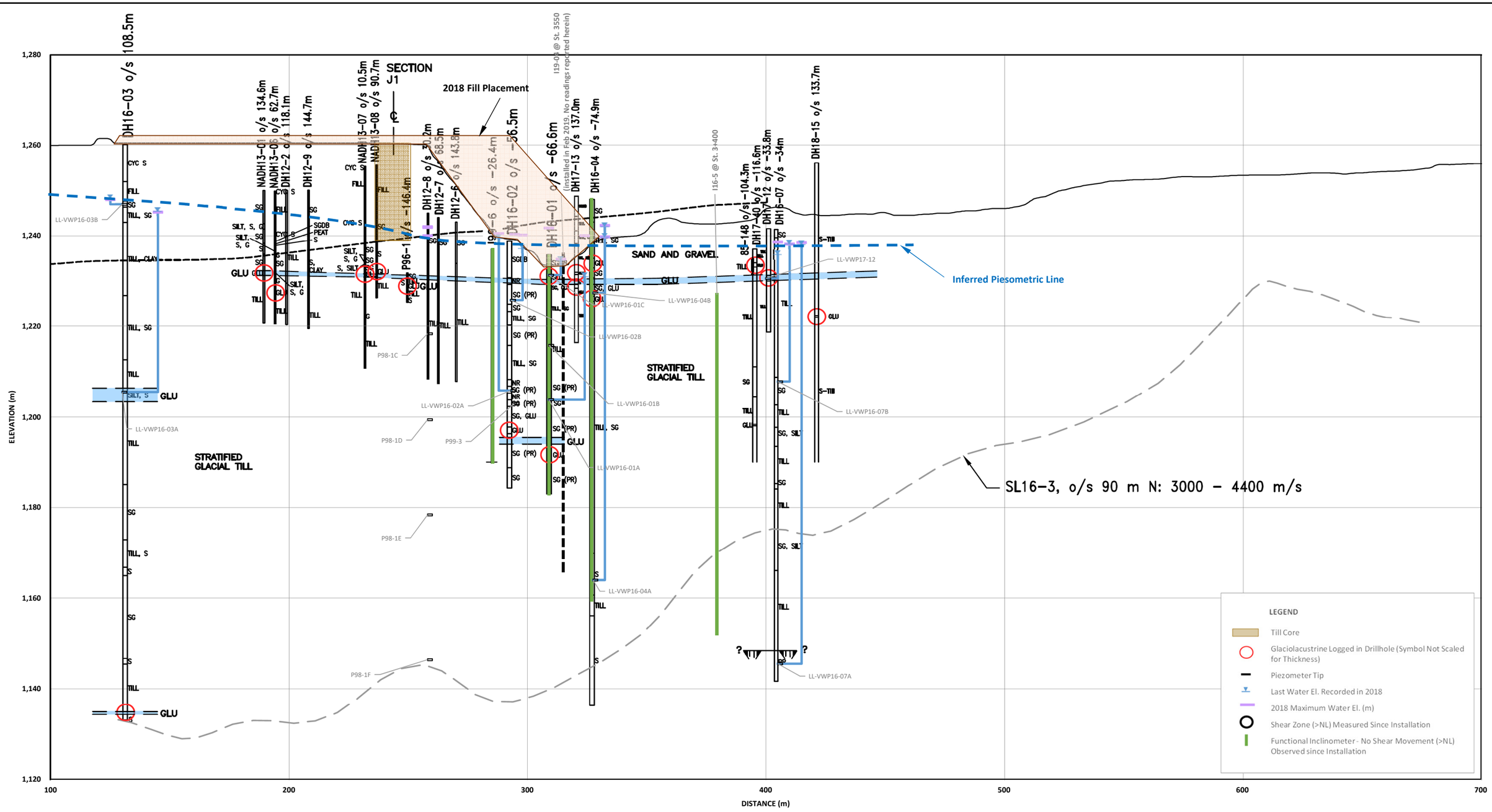
TITLE
L-L DAM
INCLINOMETER AND PIEZOMETER
CROSS SECTION LOCATION PLAN

PROJECT No. M02341B43

FIG. No. VI-1

KCB-R-MLD

Date: 2019-03-29 Time: 11:10 AM
Drawing File: \\inf.klohn.com\ProjData\M\VCR\M02341B43 - HVC 2018 Dam Safety Support\400 Drawings\CAD\Dam Safety Inspection\FIG_VI-1.dwg - PP (rschwab)



NOTES

1. The location of the instruments off the section are approximate.
2. Collar elevation of inclinometers are approximate.
3. Piezometer water elavtions are the last available readings in 2018.

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

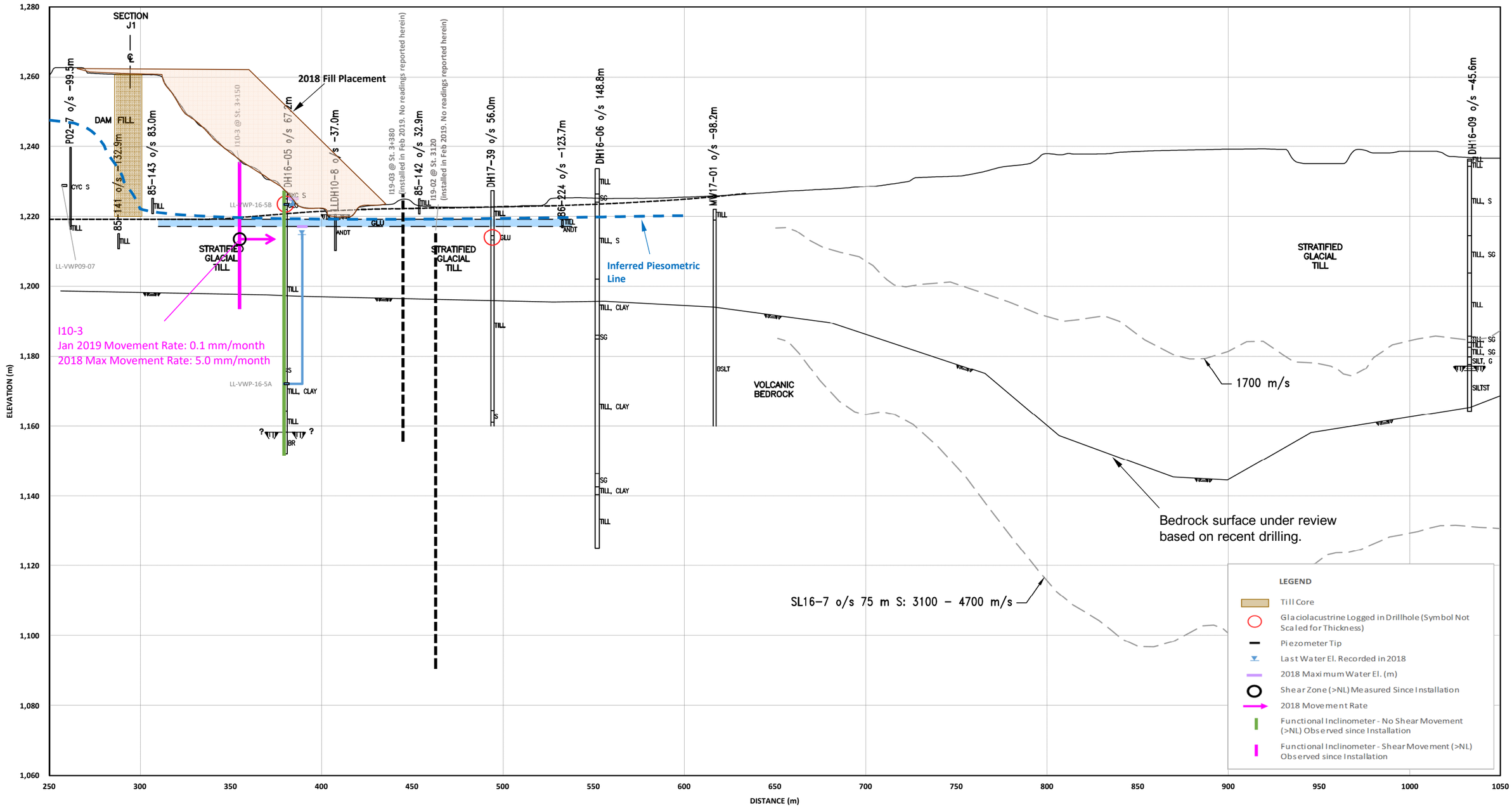
Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY SUPPORT

TITLE
L-L DAM SECTION
Sta. 3+630 - NORTH ABUTMENT
INSTRUMENT STATUS IN 2018

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	VI-02

FILE PATH: Z:\MV\VCR\M02341B43 - HVC 2018 DAM SAFETY SUPPORT\300 DESIGN\SECTIONS\INSTRUMENTATION SECTIONS (FOR 2018 DS).XLSX - 2019-03-18 13:20



NOTES

1. The location of the instruments off the section are approximate.
2. Collar elevation of inclinometers are approximate.
3. Piezometer water elavtions are the last available readings in 2018.

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CLIENT: **TECK HIGHLAND VALLEY COPPER PARTNERSHIP**

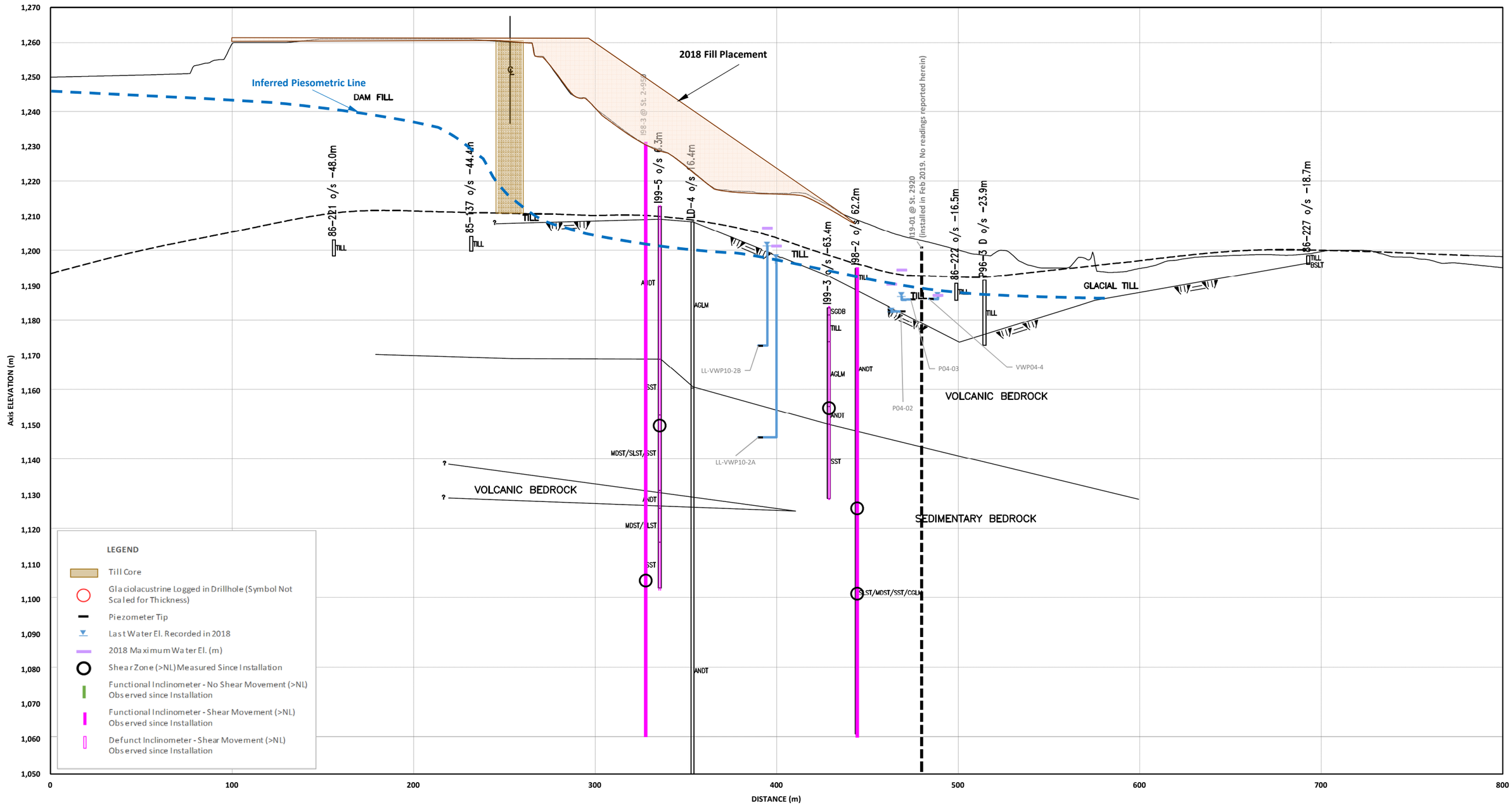
Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY SUPPORT

TITLE: L-L DAM SECTION
Sta. 3+630 - NORTH ABUTMENT
INSTRUMENT STATUS IN 2018

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	VI-03

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NOTES

1. The location of the instruments off the section are approximate.
2. Collar elevation of inclinometers are approximate.
3. Piezometer water elavtions are the last available readings in 2018.

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CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

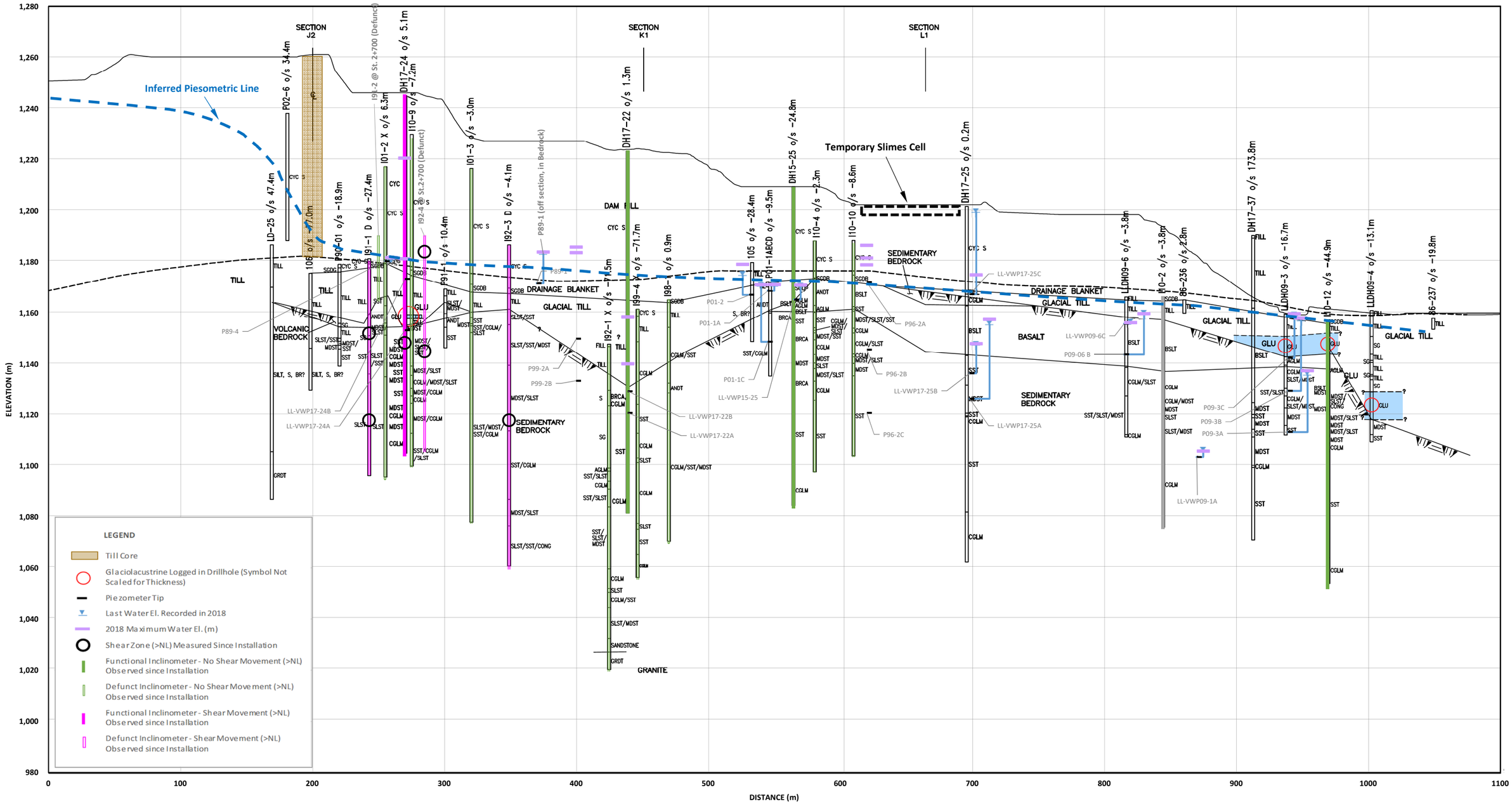
Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY SUPPORT

TITLE: L-L DAM SECTION
Sta. 3+630 - NORTH ABUTMENT
INSTRUMENT STATUS IN 2018

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	VI-04

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NOTES

1. The location of the instruments off the section are approximate.
2. Collar elevation of inclinometers are approximate.
3. Piezometer water elavtions are the last available readings in 2018.

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

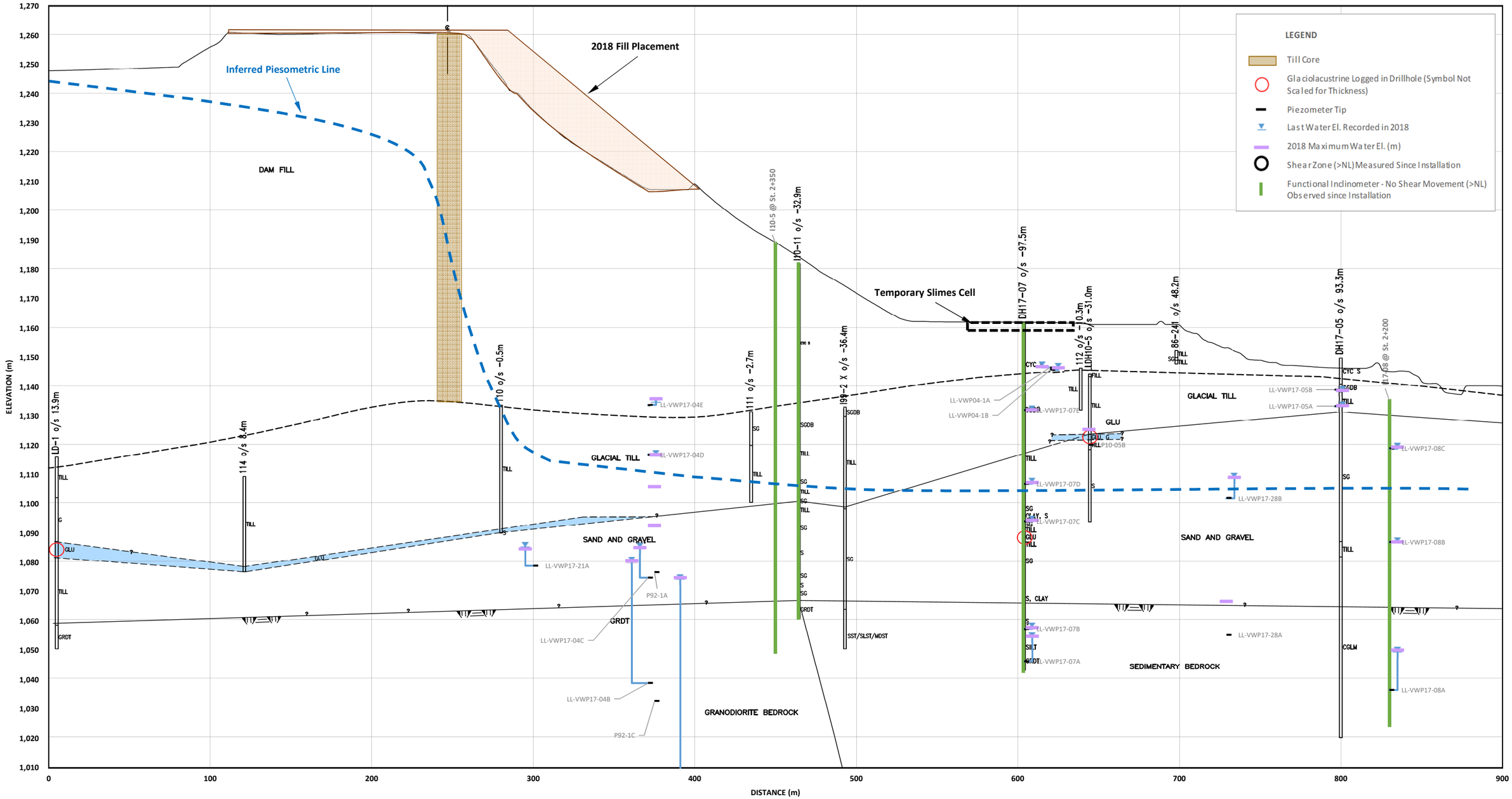
Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY SUPPORT

TITLE
L-L DAM SECTION
Sta. 3+630 - NORTH ABUTMENT
INSTRUMENT STATUS IN 2018

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	VI-05

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NOTES

1. The location of the instruments off the section are approximate.
2. Collar elevation of inclinometers are approximate.
3. Piezometer water elavtions are the last available readings in 2018.

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CLIENT: **TECK HIGHLAND VALLEY COPPER PARTNERSHIP**

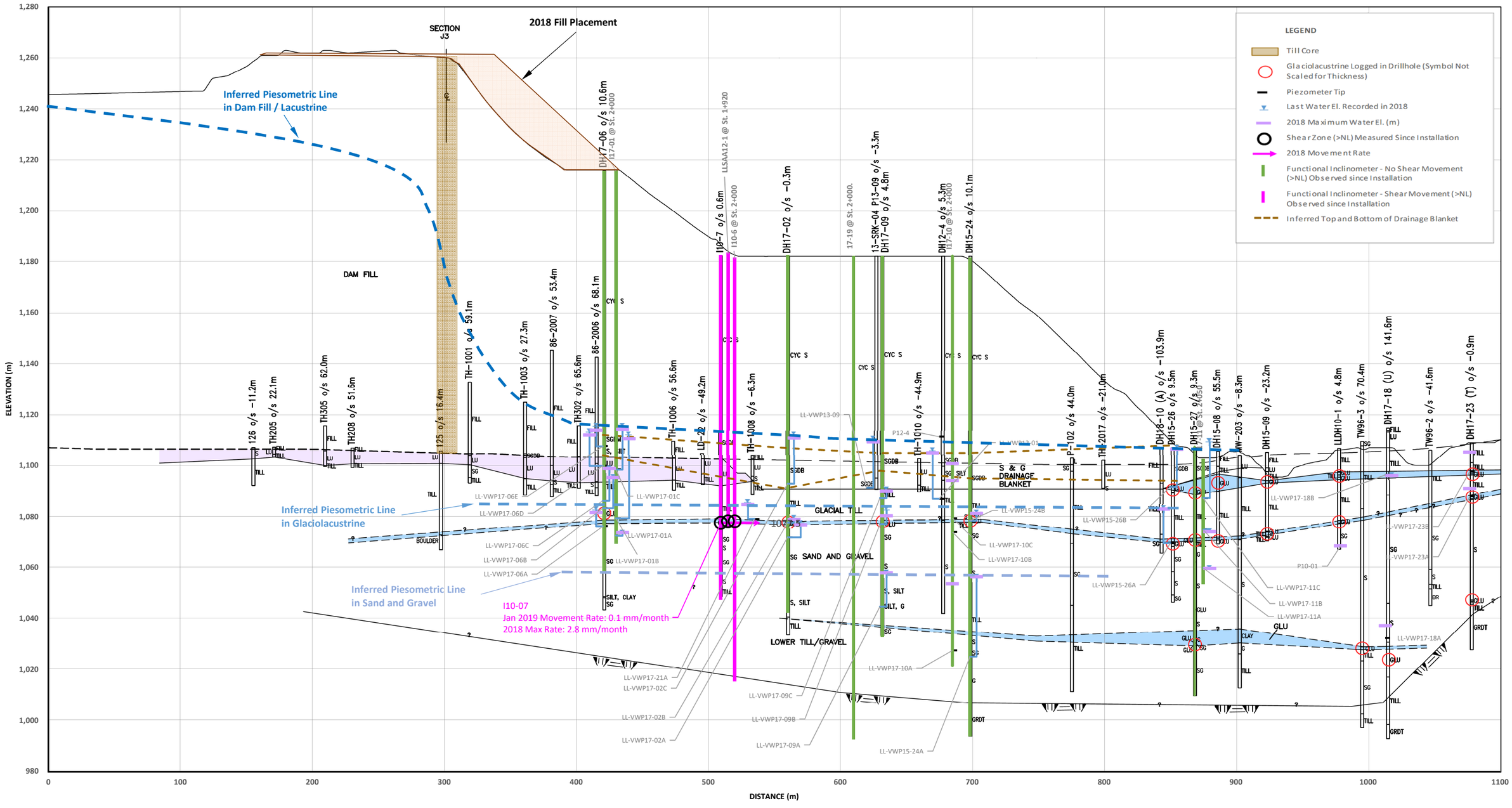
Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY SUPPORT

TITLE: L-L DAM SECTION
Sta. 3+630 - NORTH ABUTMENT
INSTRUMENT STATUS IN 2018

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	VI-06

FILE PATH: Z:\MV\GR\M02341B43 - HVC 2018 DAM SAFETY SUPPORT\300 DESIGN\SECTIONS\INSTRUMENTATION SECTIONS (FOR 2018 DSI).XLSX - 2019-03-18 13:20



NOTES

1. The location of the instruments off the section are approximate.
2. Collar elevation of inclinometers are approximate.
3. Piezometer water elavtions are the last available readings in 2018.

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CLIENT: TECK HIGHLAND VALLEY COPPER PARTNERSHIP

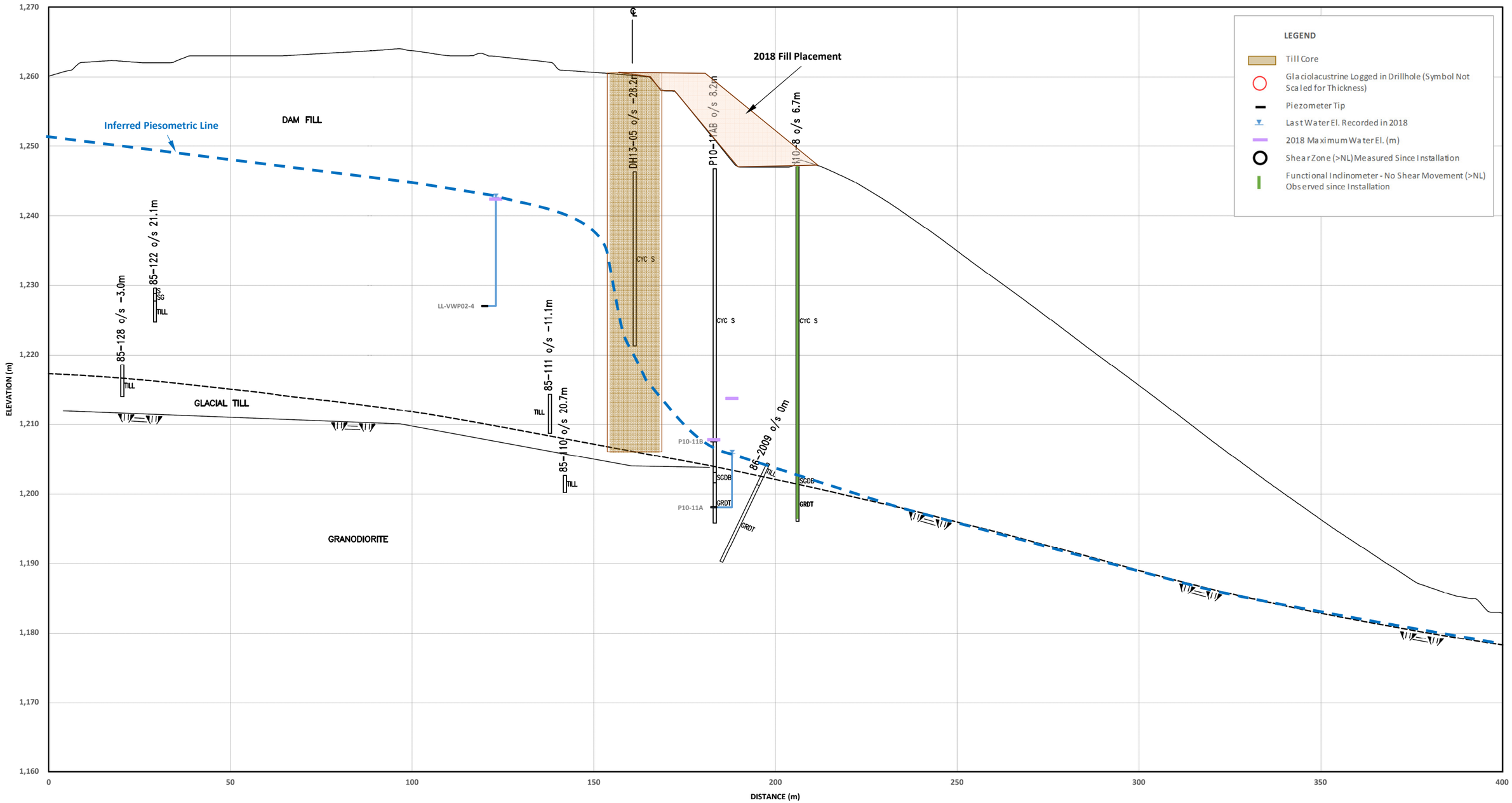
Klohn Crippen Berger

PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY SUPPORT

TITLE: L-L DAM SECTION
Sta. 3+630 - NORTH ABUTMENT
INSTRUMENT STATUS IN 2018

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	VI-07

FILE PATH: Z:\MV\CR\M02341B43 - HVC 2018 DAM SAFETY SUPPORT\300 DESIGN\SECTIONS\INSTRUMENTATION SECTIONS (FOR 2018 DSI).XLSX - 2019-03-18 13:20



NOTES

1. The location of the instruments off the section are approximate.
2. Collar elevation of inclinometers are approximate.
3. Piezometer water elavtions are the last available readings in 2018.

NOT FOR CONSTRUCTION | DRAFT

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CLIENT
TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY SUPPORT

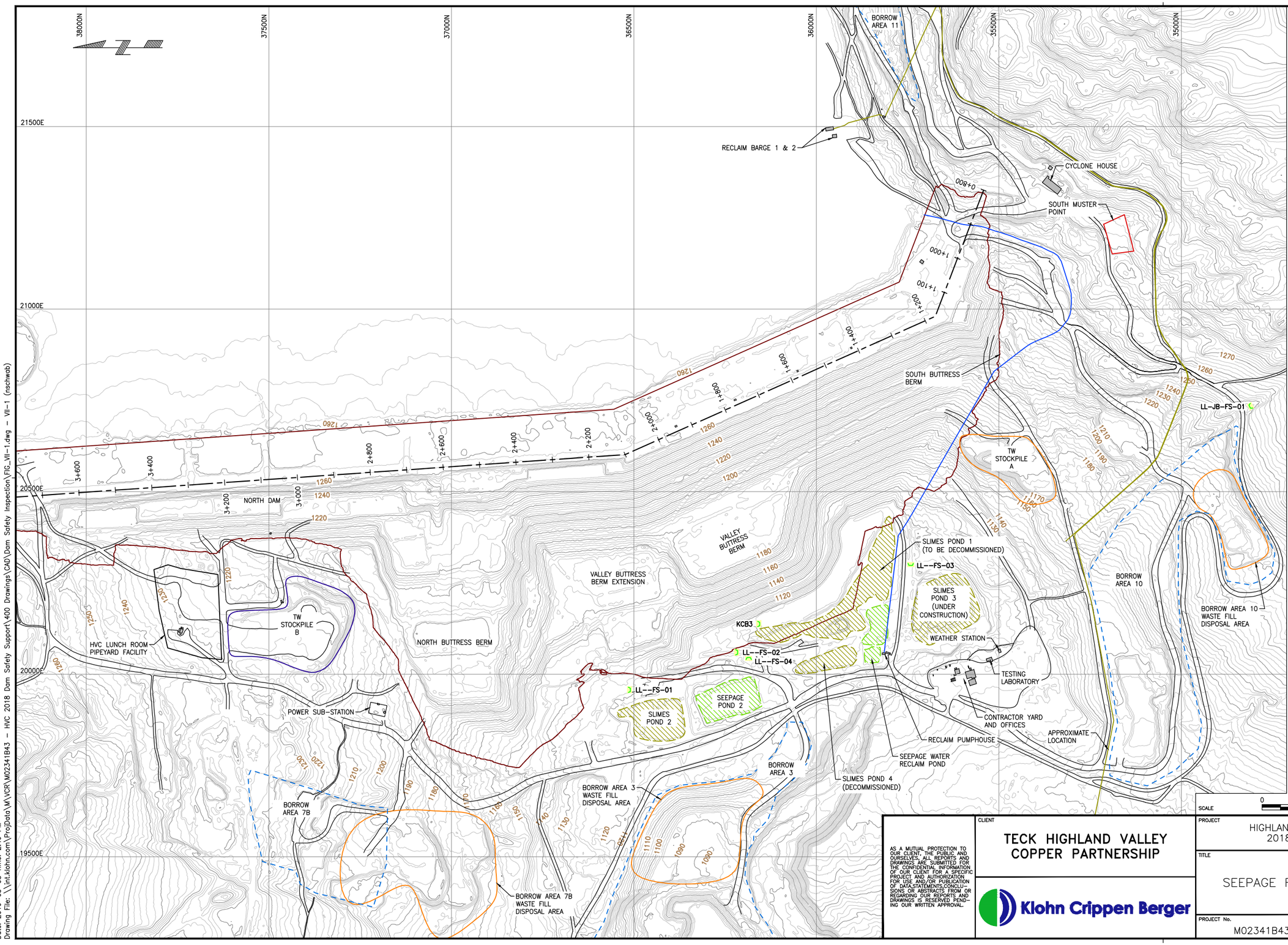
TITLE
L-L DAM SECTION
Sta. 3+630 - NORTH ABUTMENT
INSTRUMENT STATUS IN 2018

SCALE	PROJECT No.	FIG. No.
NTS	M02341B53	VI-08

FILE PATH: Z:\MV\CR\M02341B43 - HVC 2018 DAM SAFETY SUPPORT\300 DESIGN\SECTIONS\INSTRUMENTATION SECTIONS (FOR 2018 DSI).XLSX - 2019-03-18 13:20

APPENDIX VII

Seepage Flow Data Plots



LEGEND:

- BORROW AREA
- WASTE FILL DISPOSAL AREA
- SEEPAGE POND
- SLIMES POND
- EL. 1279 m ULTIMATE DAM FOOTPRINT
- SURFACE WATER RECLAIM PIPELINE
- SPATSUM WATER PIPELINE
- HAUL ROAD
- PUBLIC ROAD
- L-L DAM CENTERLINE (0+800)

ACTIVE INSTRUMENTS (SEE NOTE 2):

- SEEPAGE FLOW MONITORING WEIR

NOTES:

1. TOPOGRAPHY PROVIDED BY TECK HIGHLAND VALLEY COPPER PARTNERSHIP AND WAS DERIVED FROM SATELLITE IMAGERY TAKEN ON 2018-10-06 AND 2016-09-25 & 28.
2. ACTIVE INSTRUMENTS ARE DEFINED AS ANY INSTRUMENTS SATISFYING ONE OF THE FOLLOWING CRITERIA: CURRENTLY READING AN ACTIVE WATER LEVEL, DRY OR PLUGGED <20 m ABOVE TIP ELEVATION AS THIS COULD SHOW A RESPONSE IN THE FUTURE.
3. PUKAIST CREEK WEIR IS NOT SHOWN AND IS LOCATED AT E 17448 N 34452.

THVCP WEIR NAME	KCB WEIR NAME
LL--FS-01	FINGER DRAIN #1
LL--FS-02	UVD/LVD
LL--FS-03	POINT B
LL--FS-04	SEEPAGE POND 2
KCB3	POINT A
LL-JB-FS-01	POINT D

SCALE 0 250 m

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TECK HIGHLAND VALLEY COPPER PARTNERSHIP

Klohn Crippen Berger

PROJECT
HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

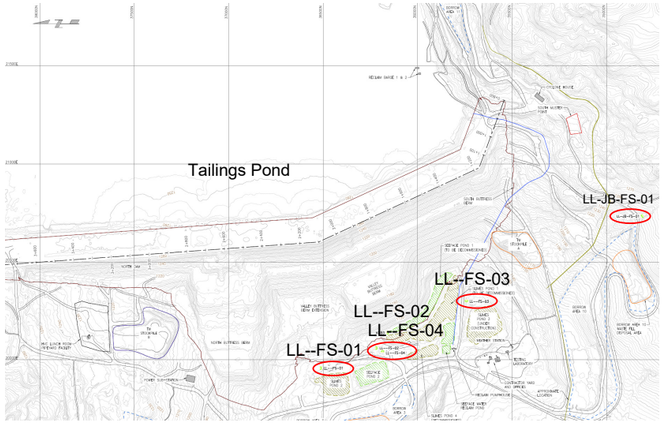
TITLE
L-L DAM
SEEPAGE FLOW MONITORING STATIONS

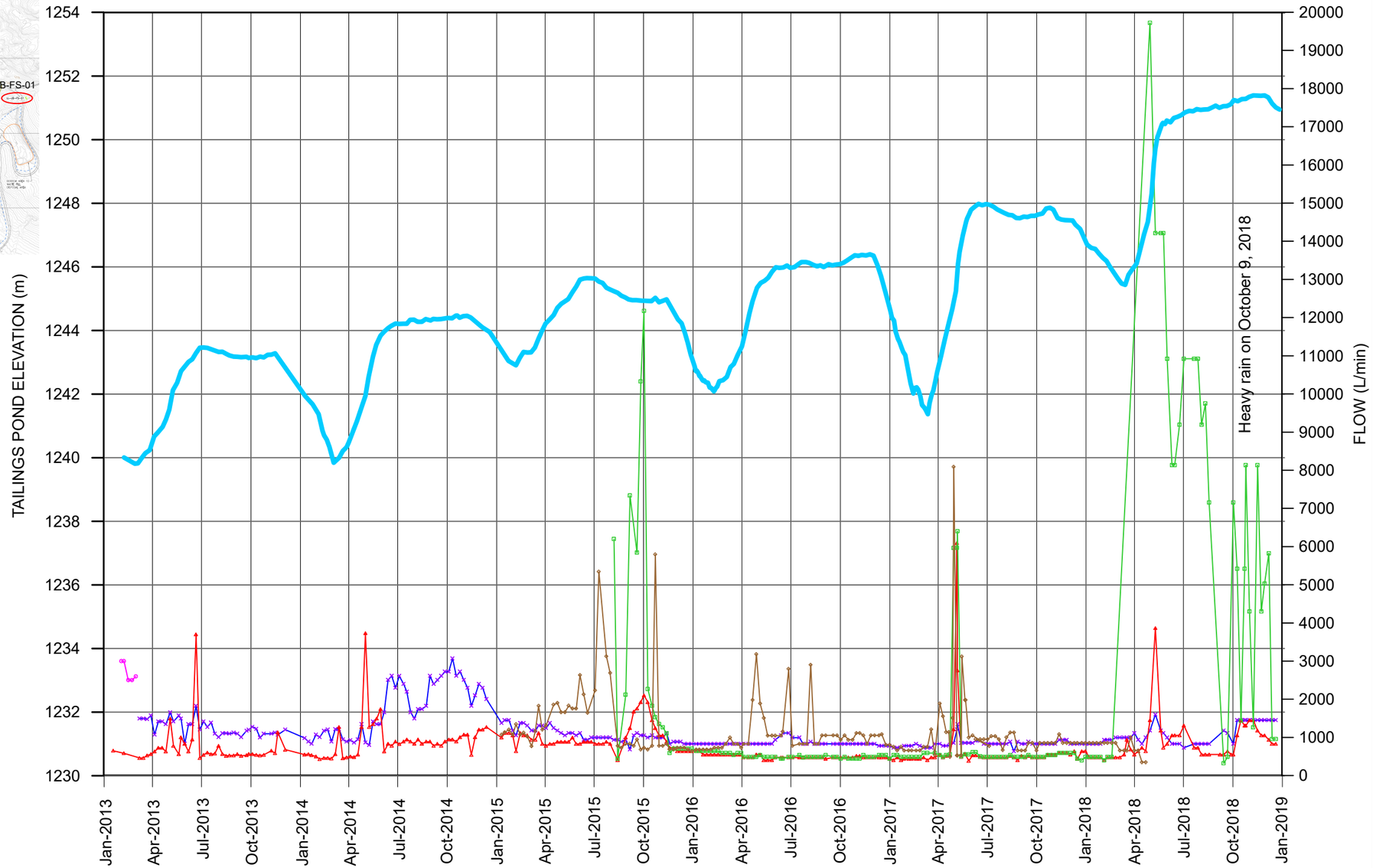
PROJECT No. M02341B43

FIG. No. VII-1

KCB-R-MLD

Date: 2019-03-08 Time: 2:49 PM
Drawing File: \\inl.klohn.com\ProjData\M\VCR\M02341B43 - HVC 2018 Dam Safety Support\400 Drawings\CAD\Dam Safety Inspection\FIG_VII-1.dwg - VII-1 (nschwab)





LEGEND

- LL--FS-01
- LL--FS-02
- LL--FS-04
- LL--FS-02 plus LL--FS-01 Combined Flows (2012 to Mar-2013)
- Seepage from VBB Toe (LL--FS-03 minus LL-JB-FS-01)
- Tailings Pond

KCB Weir Name	THVCP Weir Name
Finger Drain #1	LL--FS-01
UVD/LVD	LL--FS-02
Point B	LL--FS-03
Seepage Pond 2 Weir	LL--FS-04
Point D	LL-JB-FS-01
Pukaist Weir	OS-PC-FS-02

Notes:
In 2016, OS-PC-FS-02 was measured using a datalogger. One manual reading of the weir by THVCP suggested that the datalogger was reading lower than actual flow rates.
As of June 2018, the seepage pond was backfilled and there was no seepage reporting to LL--FS-03.

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PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

TITLE: L-L DAM POND LEVEL AND SEEPAGE FLOW 2013-2018

PROJECT No. M02341B43

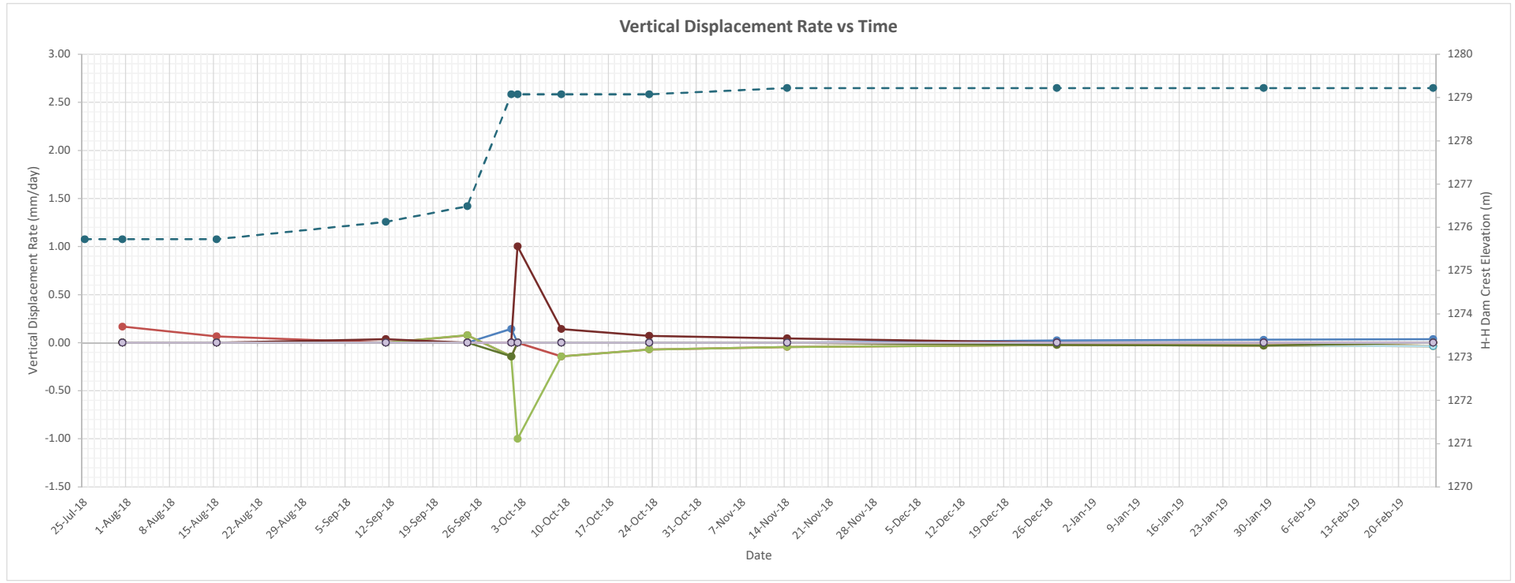
FIG No. VII-2

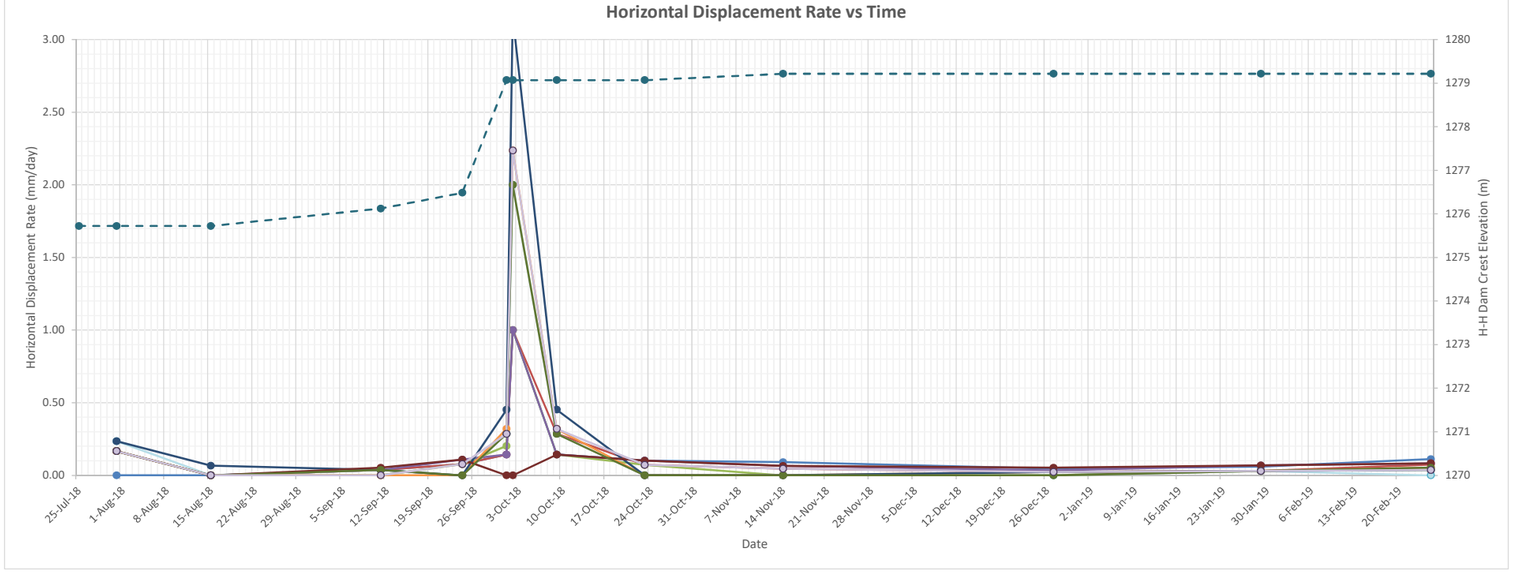
Date: March 14, 2019
\\int.klohn.com\Proj\Data\MIVCR\M02341B43 - HVC 2018 Dam Safety Support\300 Design\Seepage Data\Highland\Seepage (2018 DSI).grf

APPENDIX VIII

H-H Lock-Block Wall Monument Data Plots







Legend:
- LB1
- LB2
- LB3
- LB4
- LB5
- LB6
- LB7
- LB8
- LB9
- LB10
- H-H Till Core Elv. at 2+000 (Right Axis)

NOTES:

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PROJECT: HIGHLAND TAILINGS STORAGE FACILITY
2018 DAM SAFETY INSPECTION

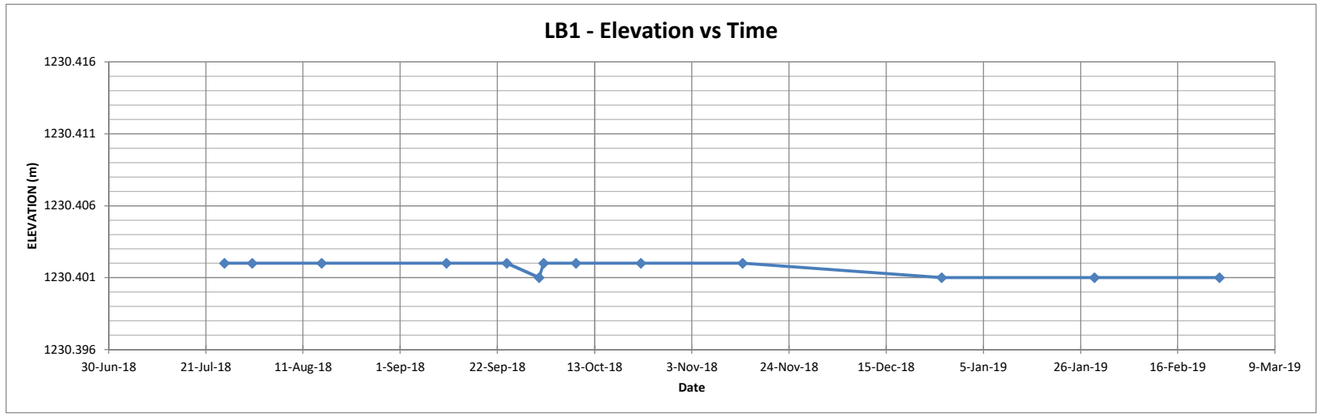
TITLE: H-H DAM LOCK-BLOCK RETAINING WALL SURVEY MONUMENT READINGS SUMMARY

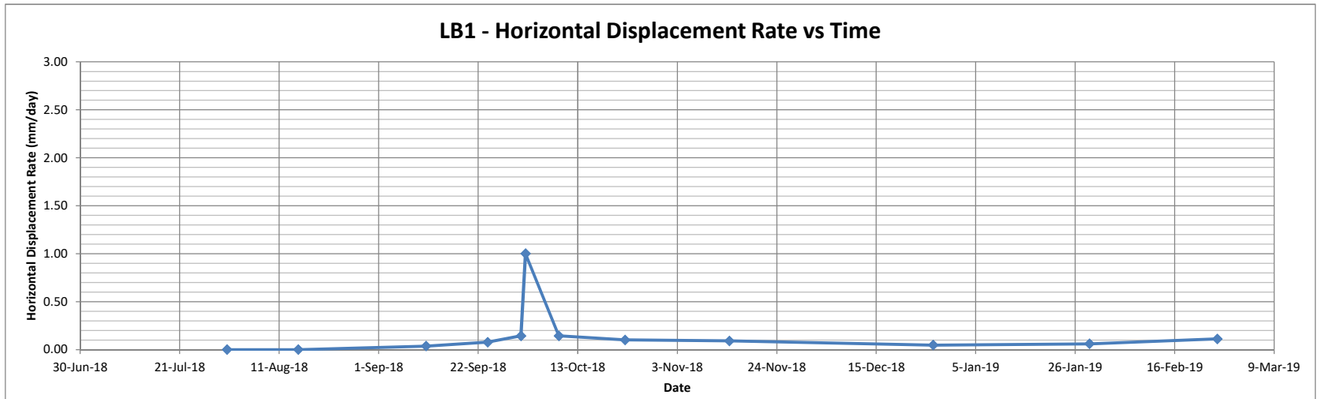
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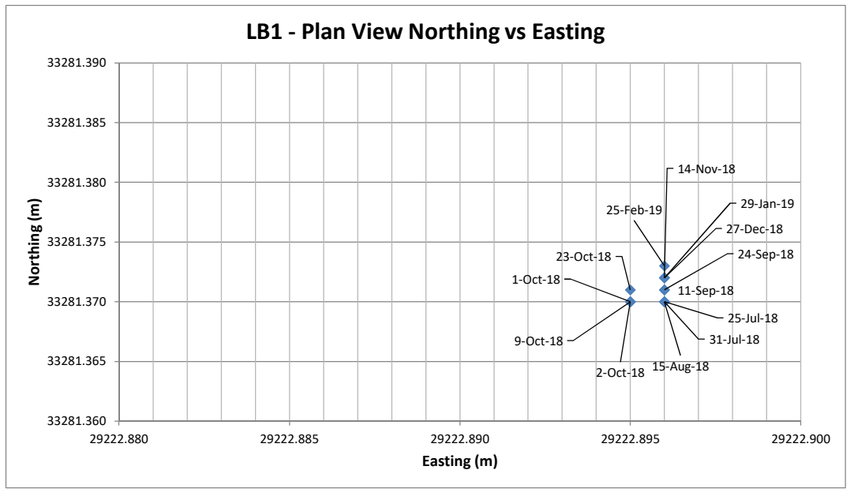
FIG No. VIII-1

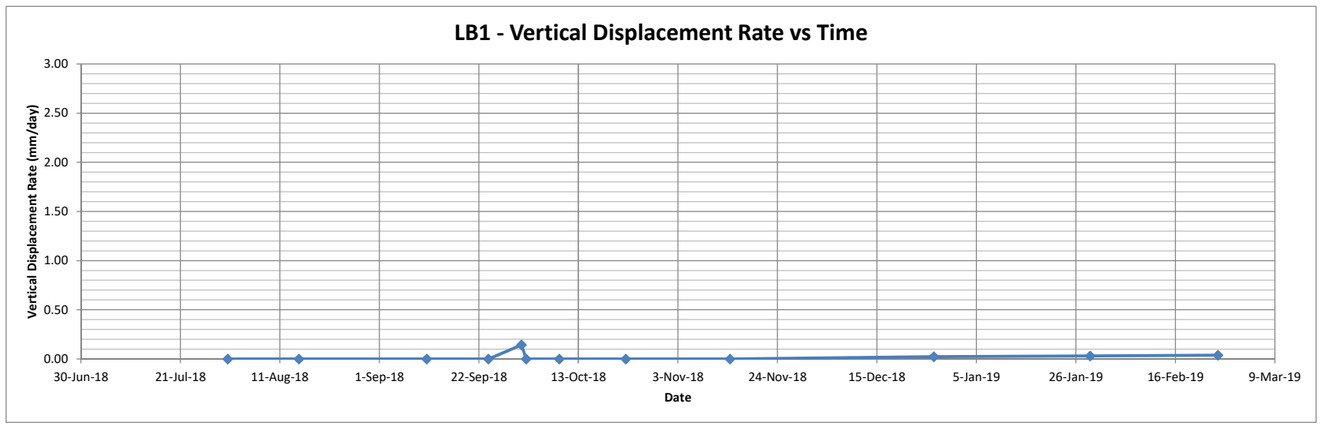
March 20, 2019
\\nt\Klohn.com\Proj\Data\M\VCR\M02341B43 - HVC 2018 Dam Safety Support\300 Design\Monument Data\H-H Dam\(190319 HH Pumphouse Retaining Wall Monitoring DSI Figs.xlsm)PLOT ALL











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2018 DAM SAFETY INSPECTION

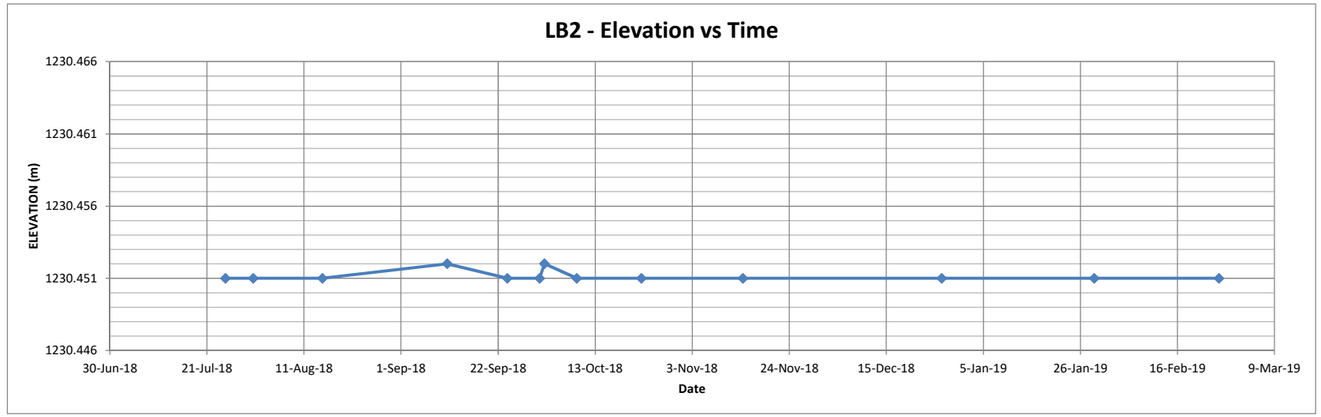
TITLE
H-H DAM LOCK-BLOCK RETAINING WALL
SURVEY MONUMENT READINGS
LB1

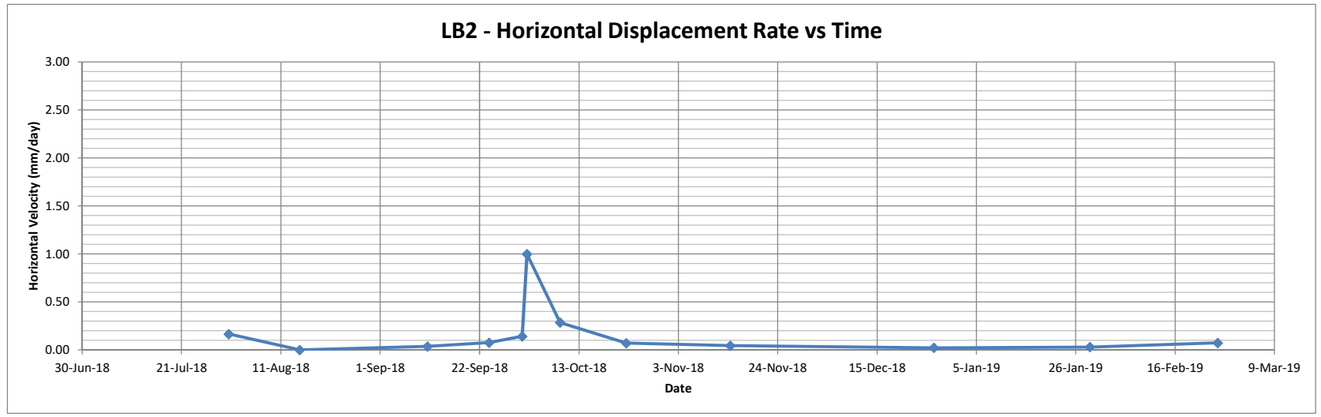
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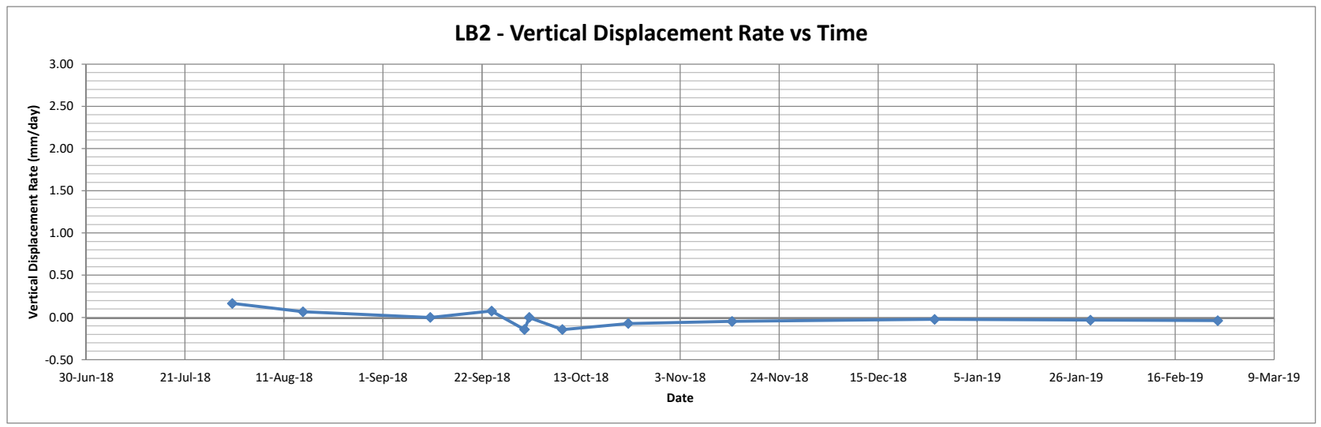
FIG No. VIII-2

March 20, 2019
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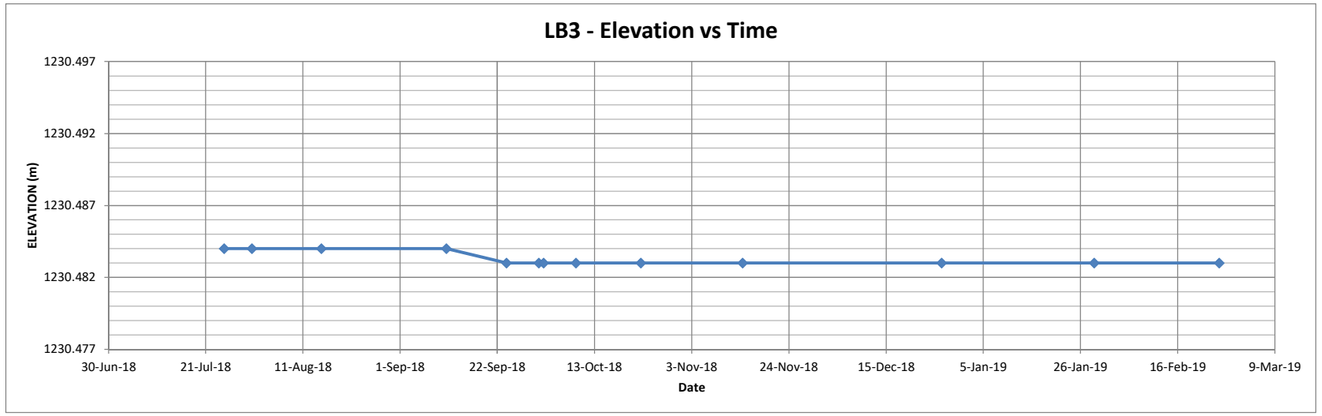
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SURVEY MONUMENT READINGS
LB2

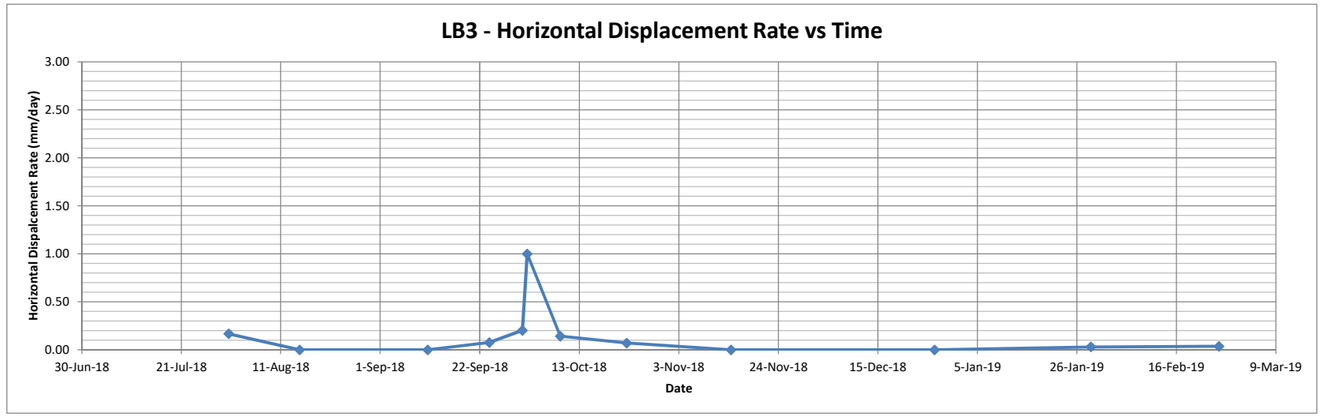
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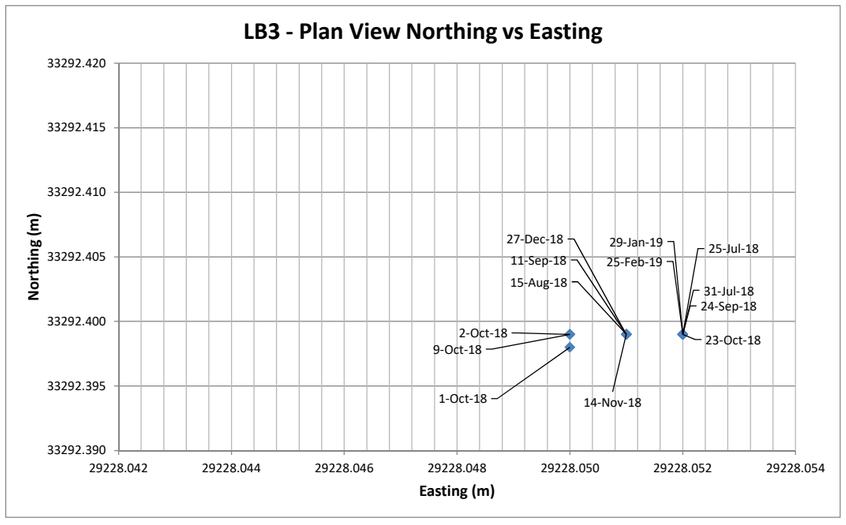
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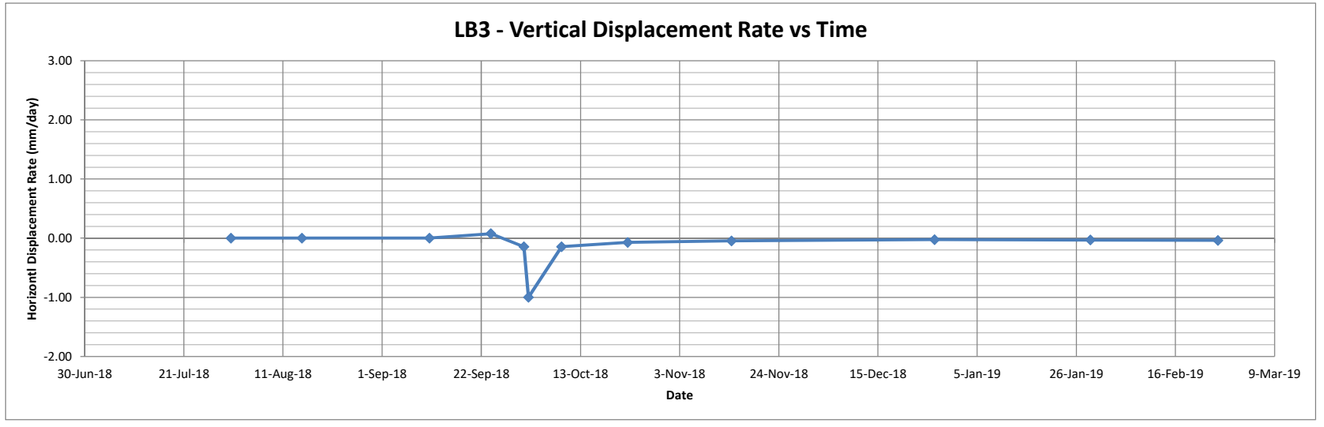
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2018 DAM SAFETY INSPECTION

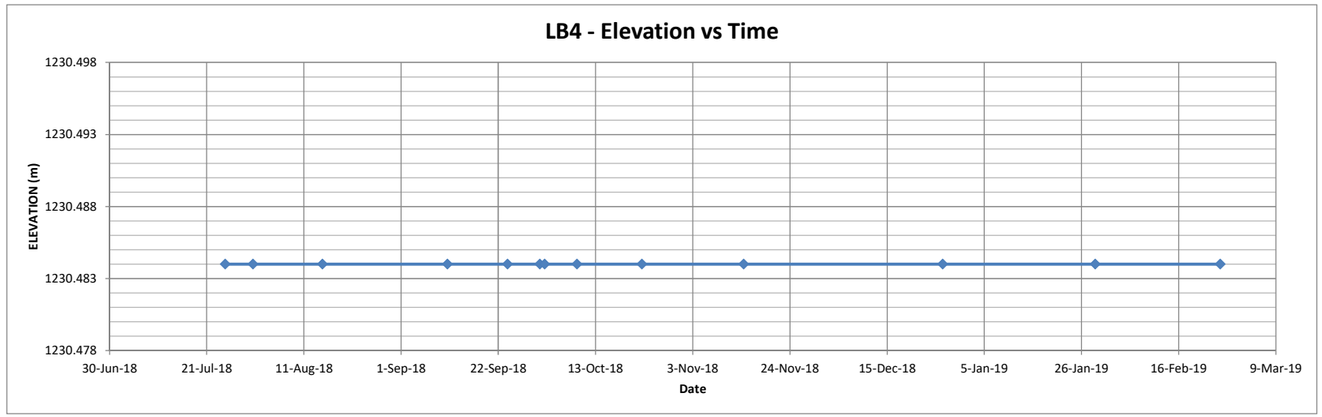
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SURVEY MONUMENT READINGS
LB3

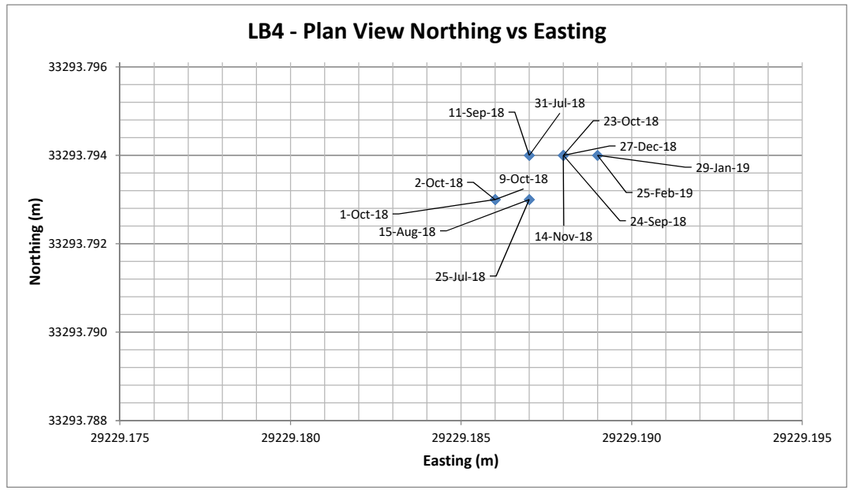
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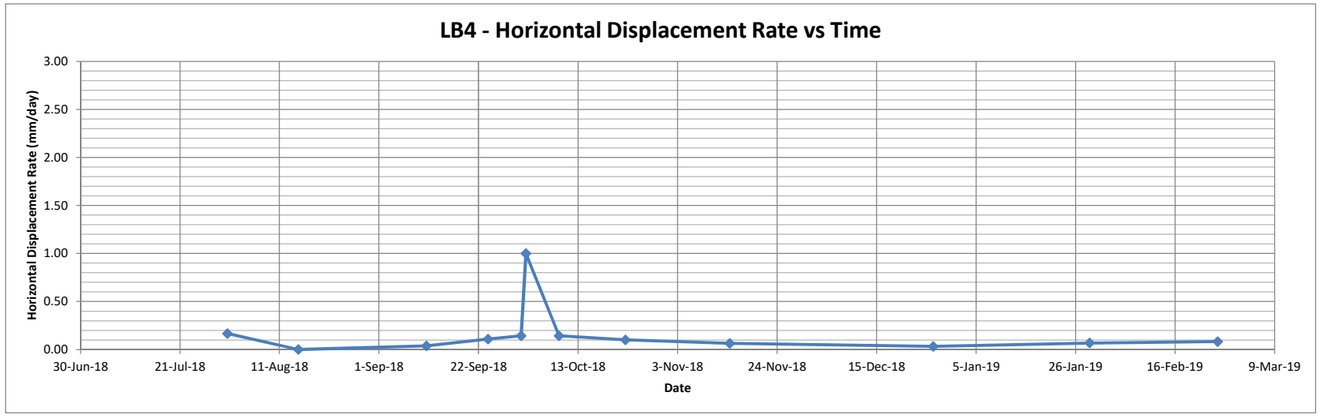
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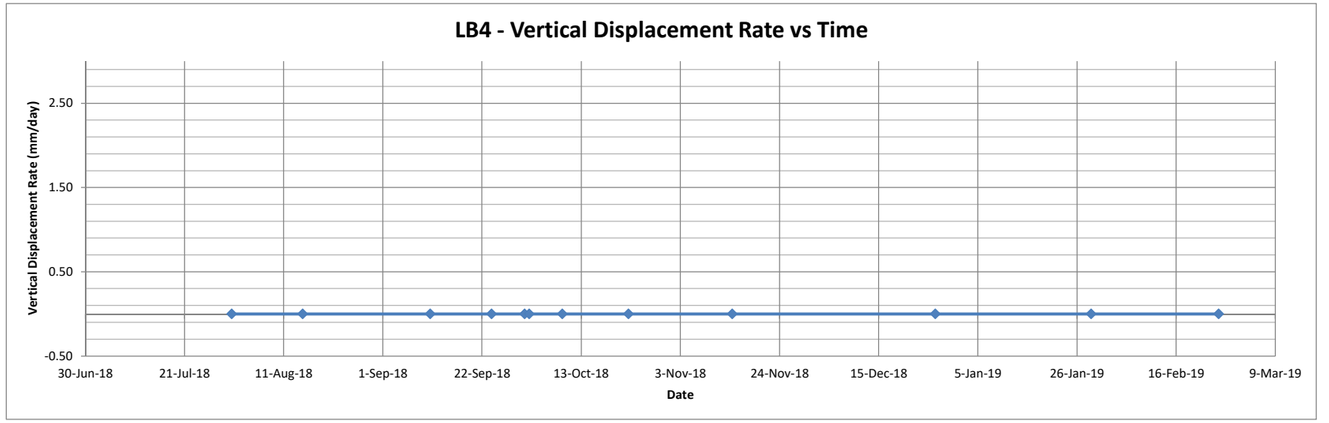
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2018 DAM SAFETY INSPECTION

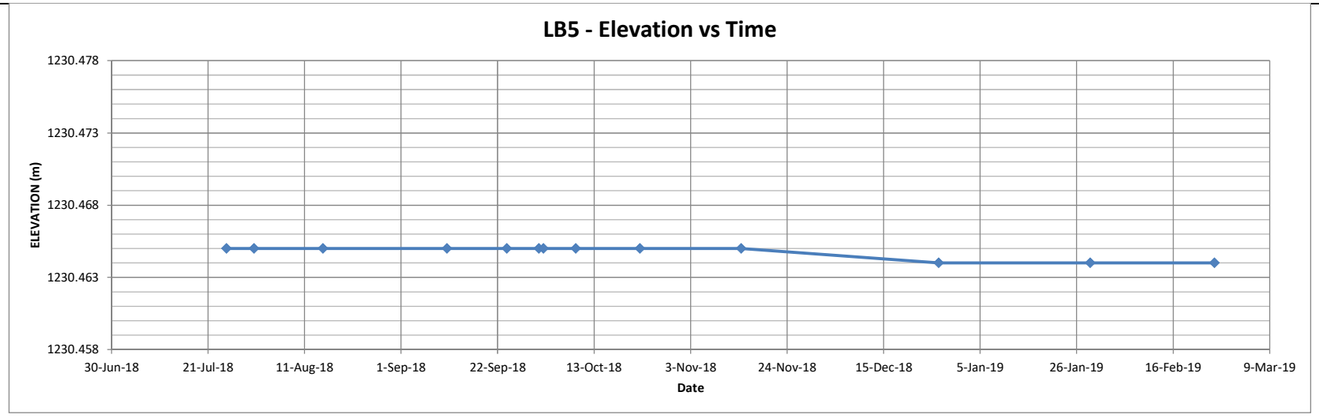
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SURVEY MONUMENT READINGS
LB4

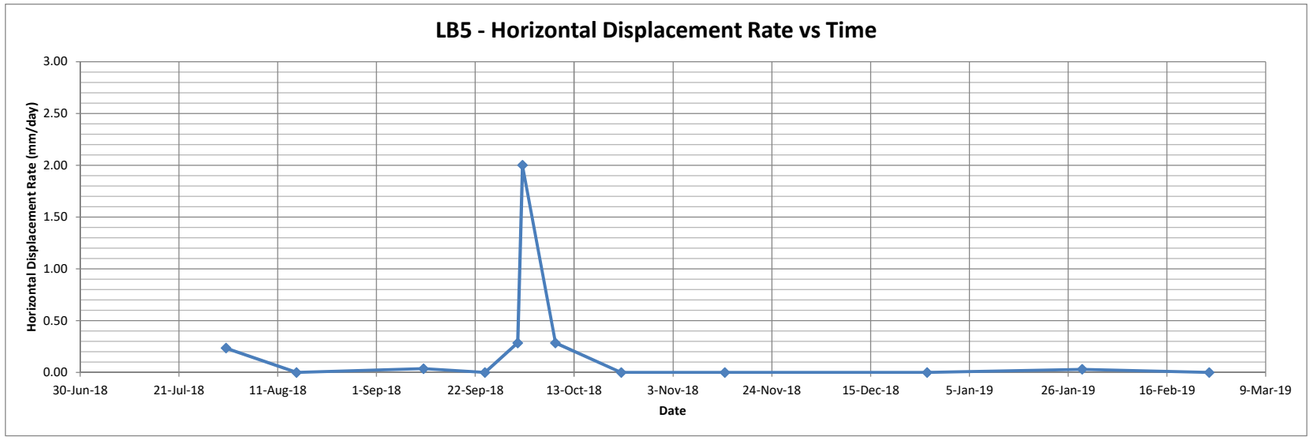
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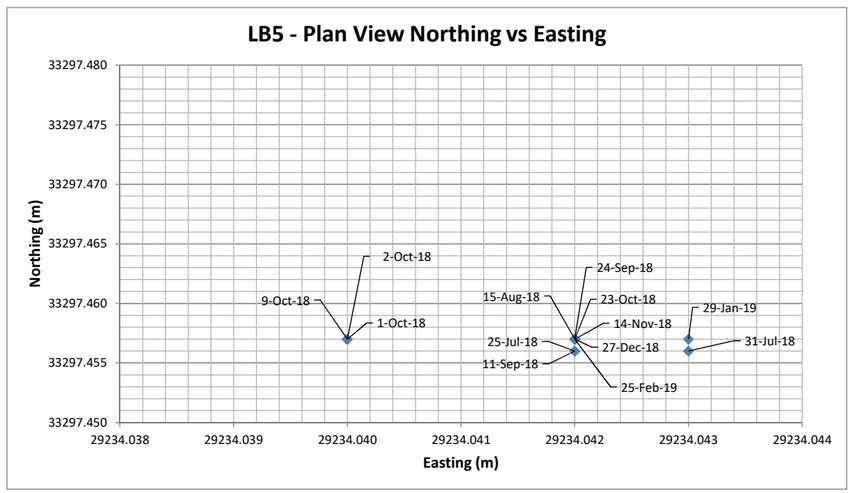
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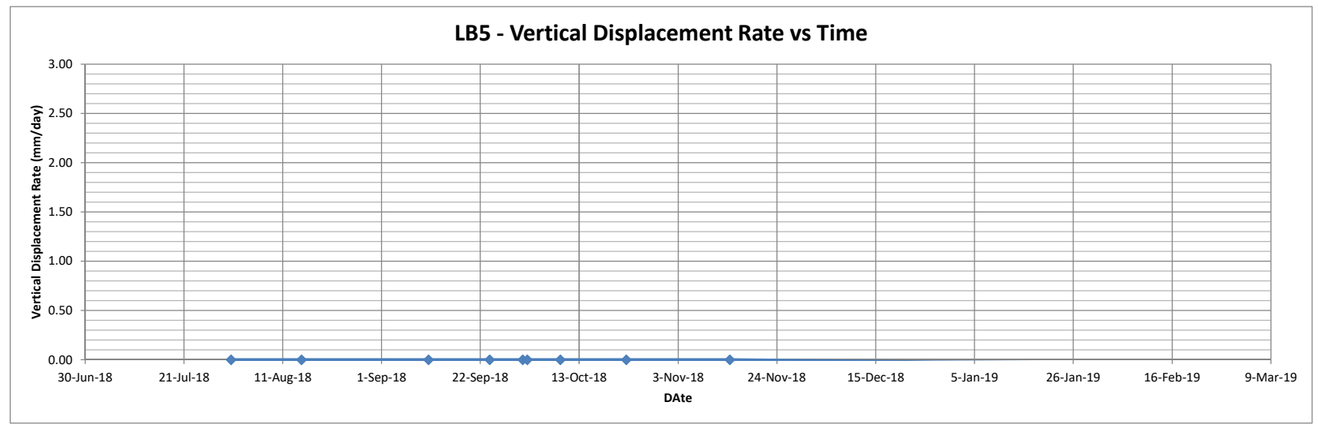
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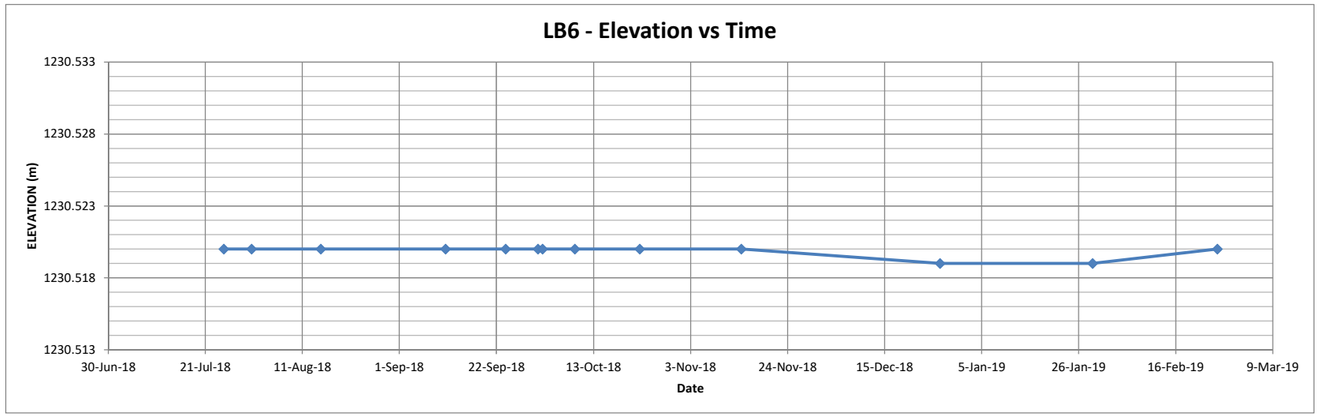
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SURVEY MONUMENT READINGS
LB5

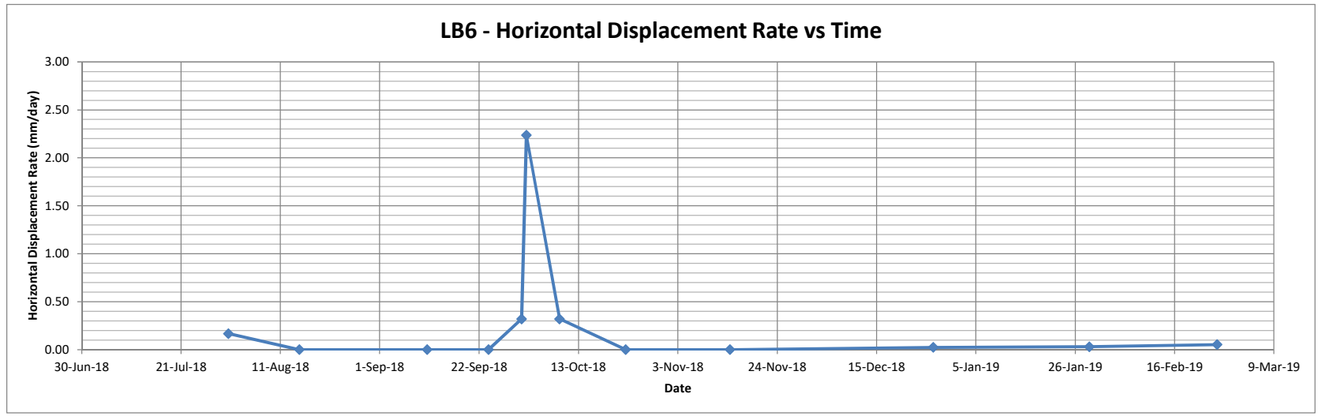
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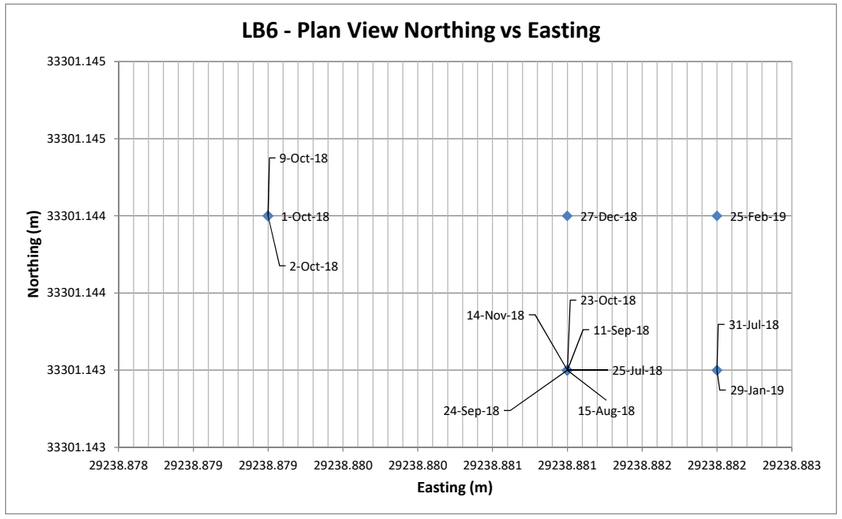
FIG No. VIII-6

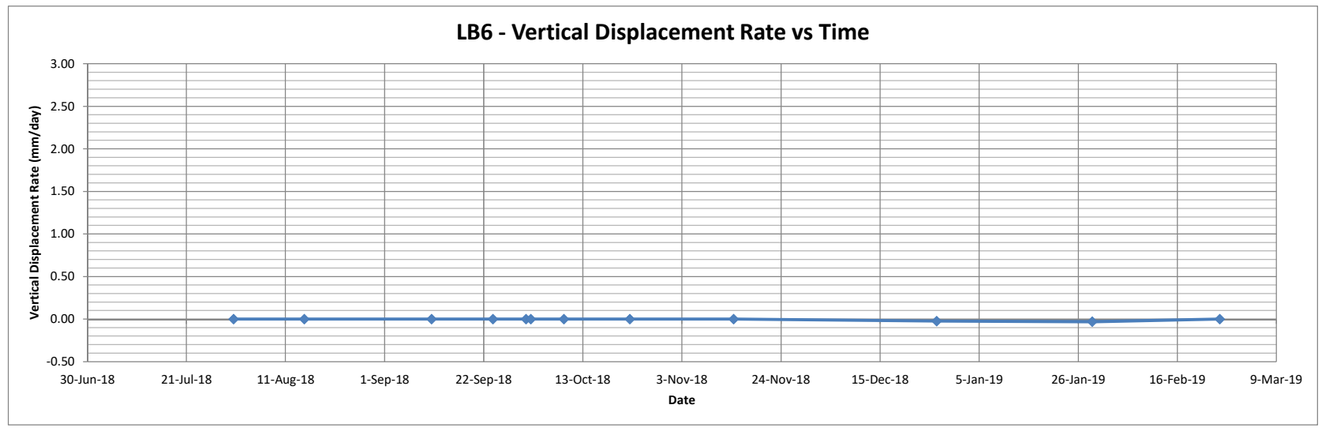
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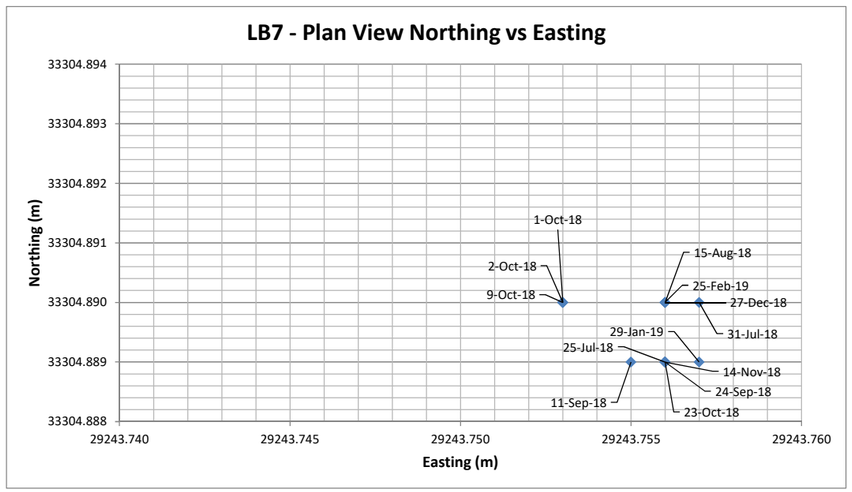
TITLE
H-H DAM LOCK-BLOCK RETAINING WALL
SURVEY MONUMENT READINGS
LB6

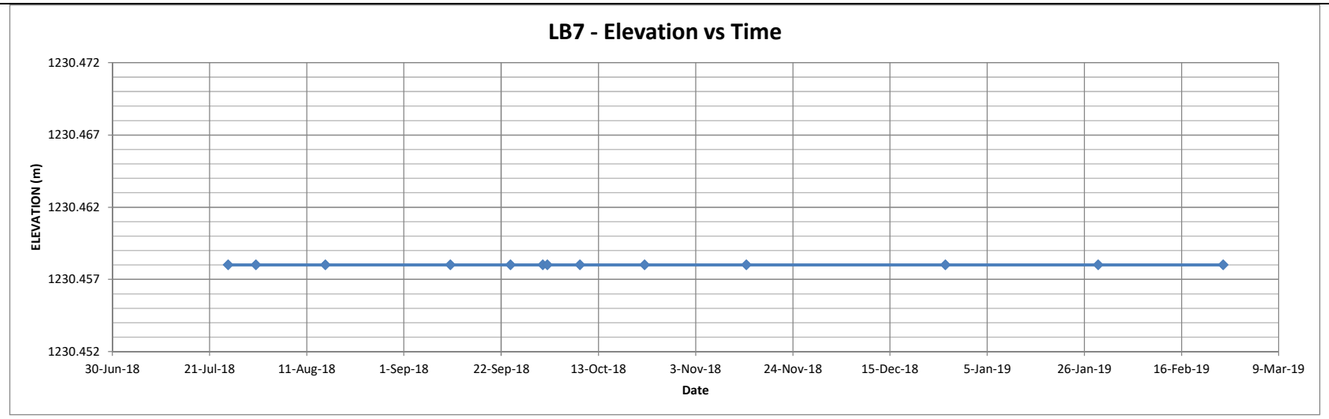
PROJECT No. M02341B43

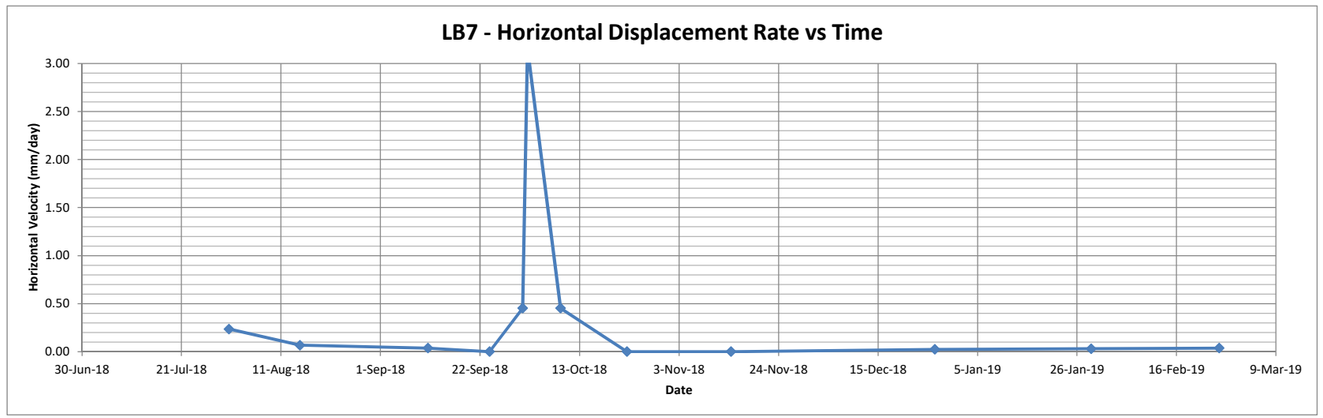
FIG No. VIII-7

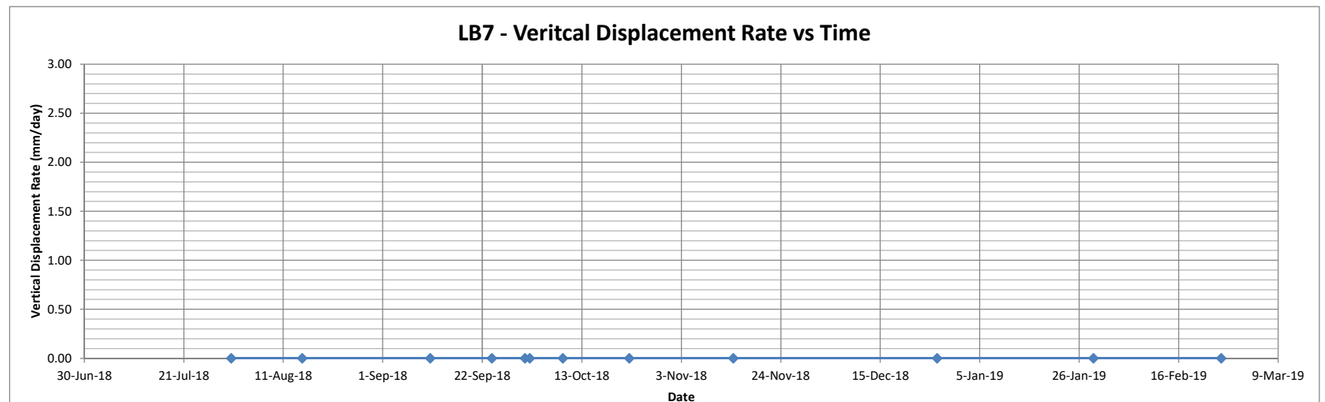
March 20, 2019
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PROJECT
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2018 DAM SAFETY INSPECTION

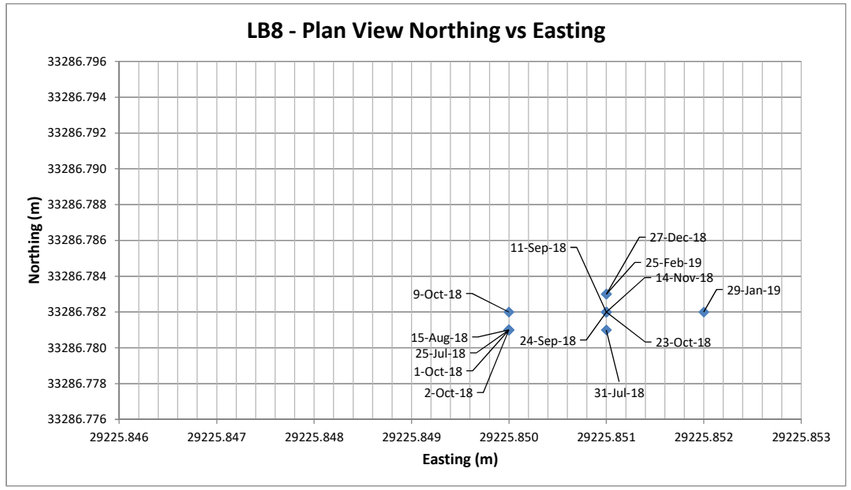
TITLE
H-H DAM LOCK-BLOCK RETAINING WALL
SURVEY MONUMENT READINGS
LB7

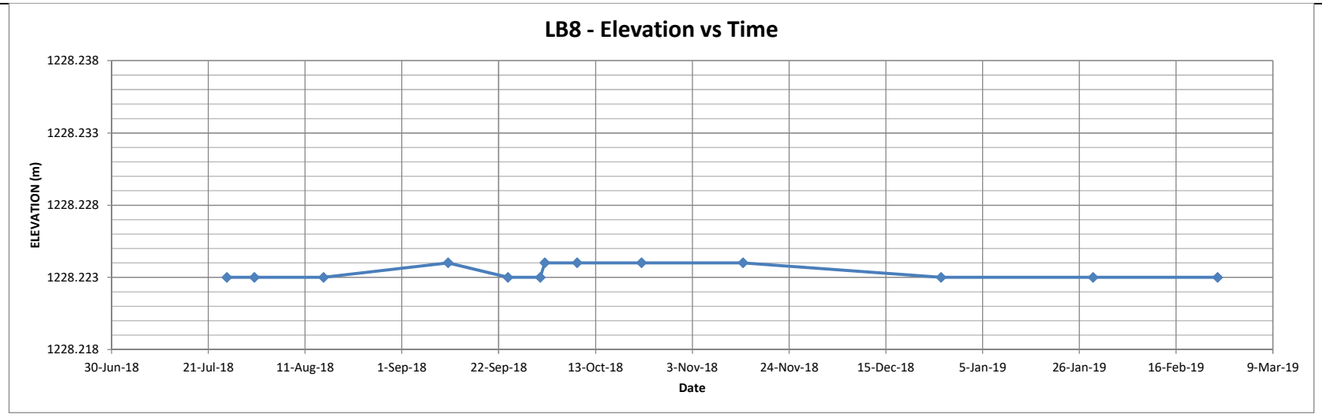
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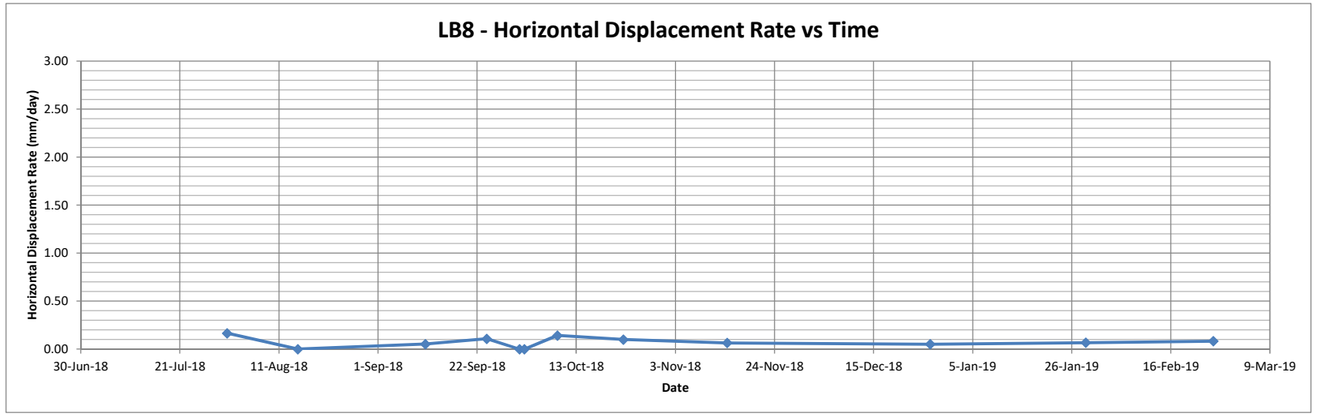
FIG No. VIII-8

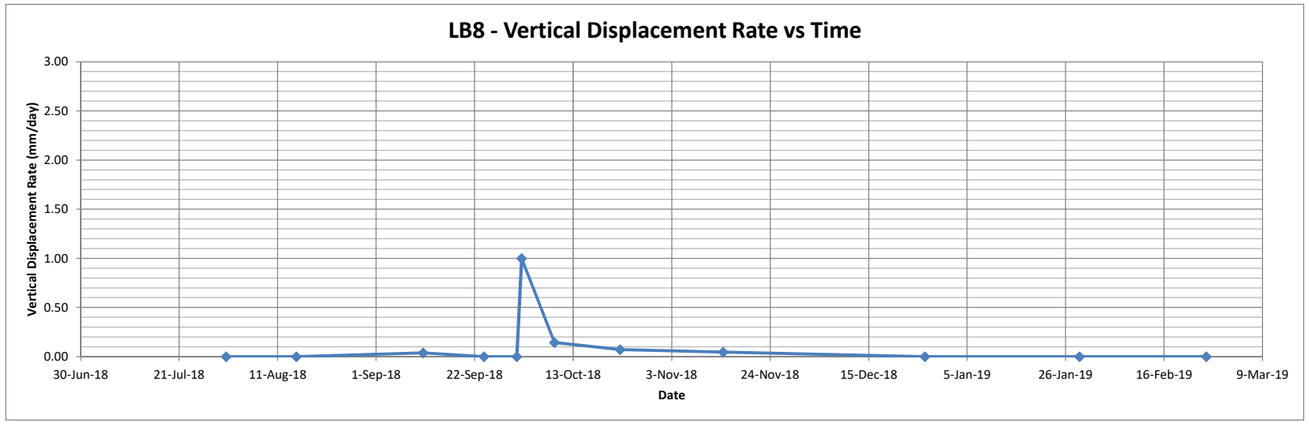
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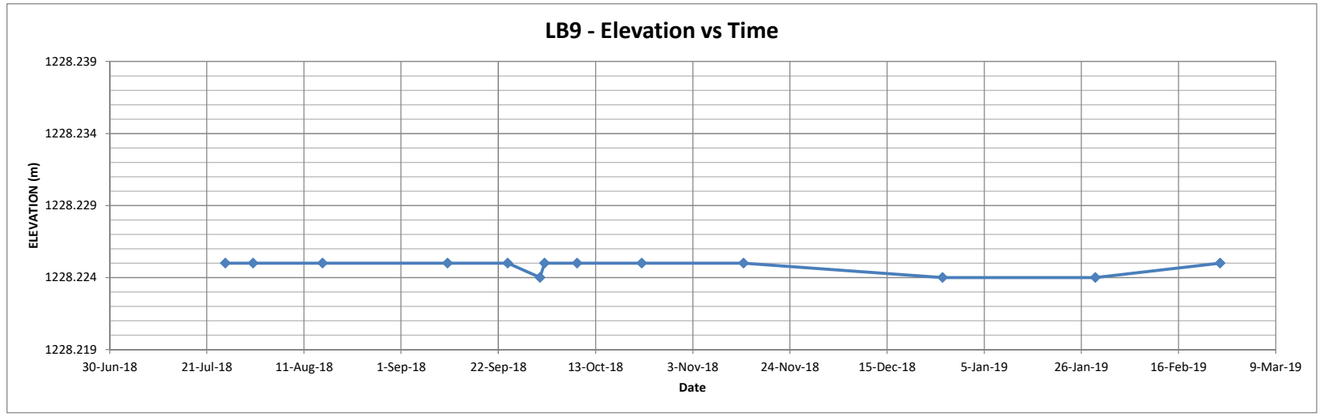
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SURVEY MONUMENT READINGS
LB8

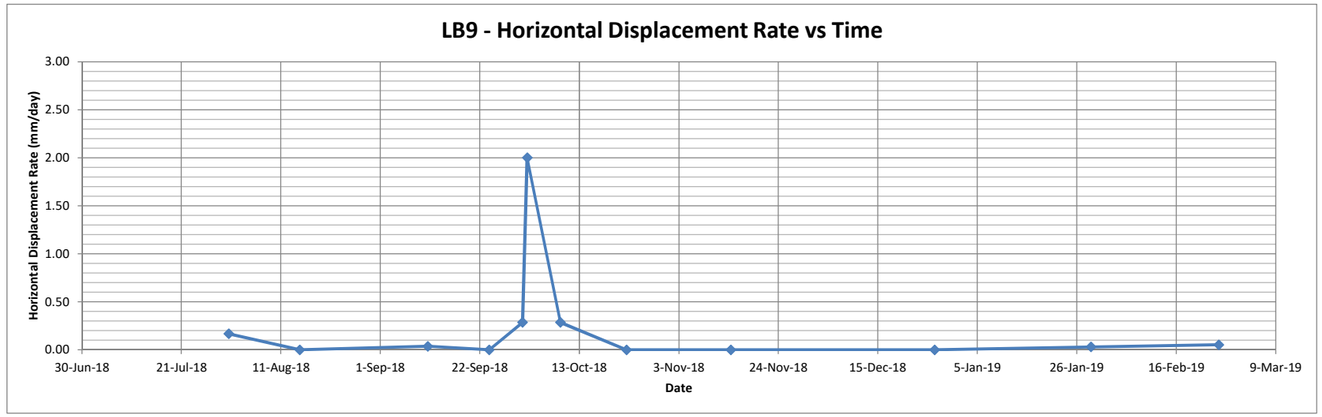
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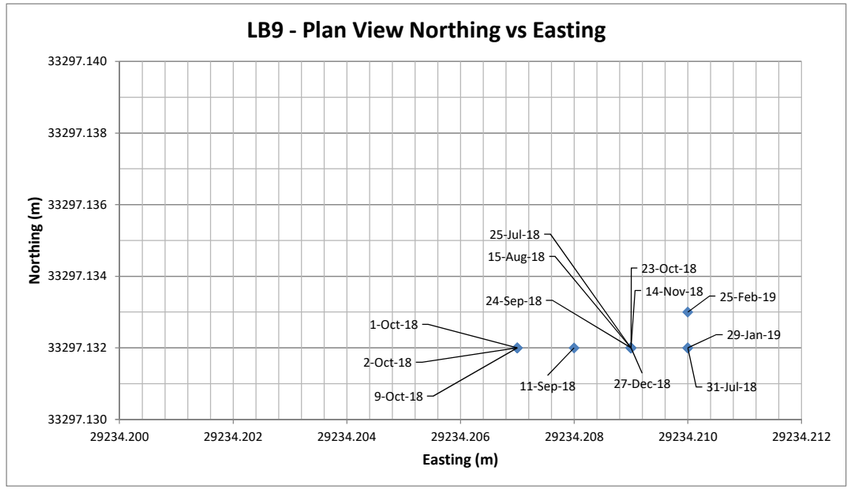
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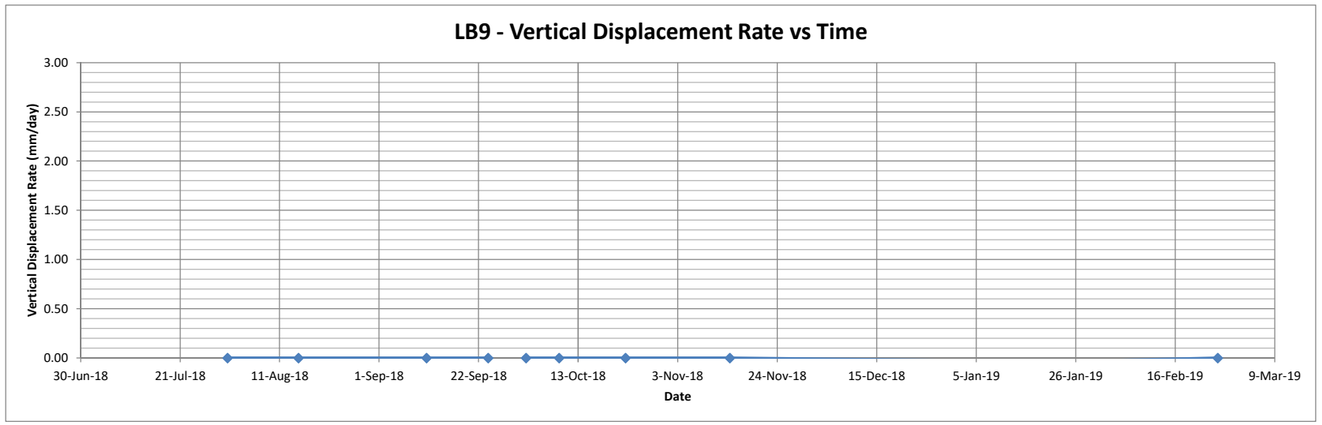
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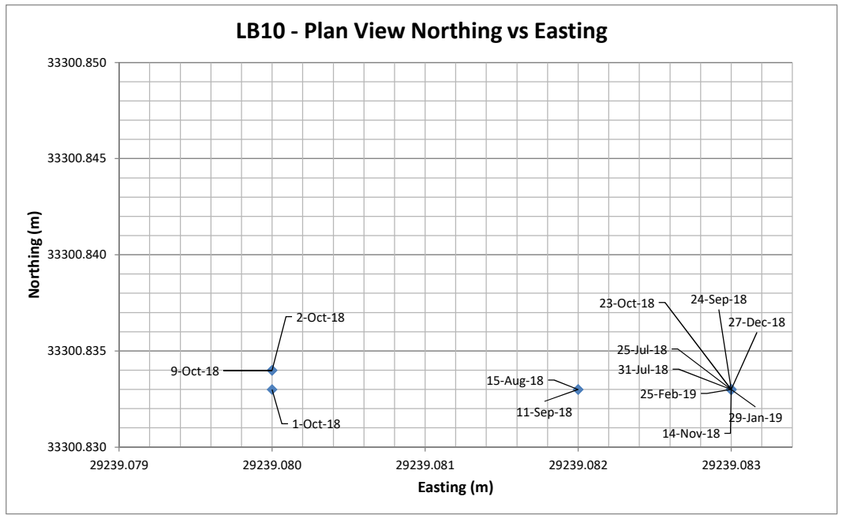
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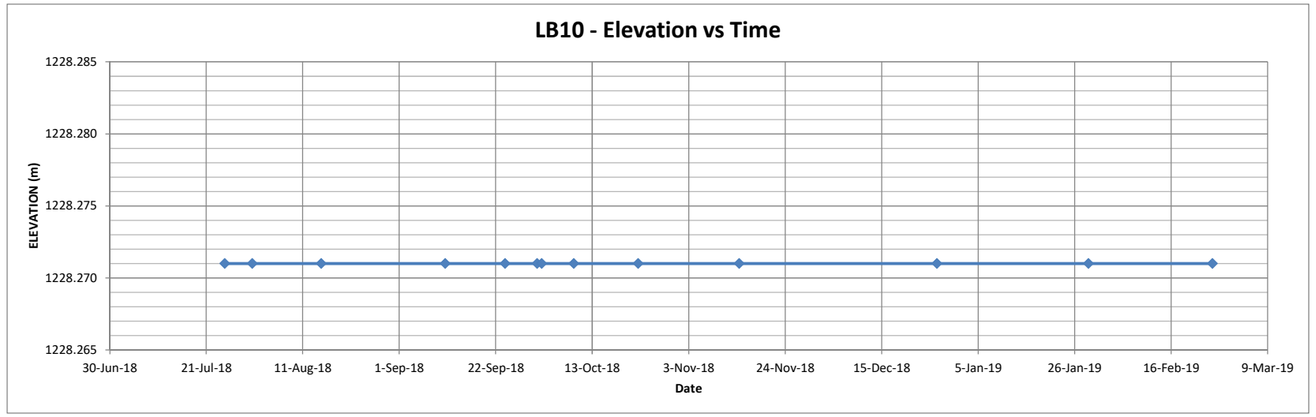
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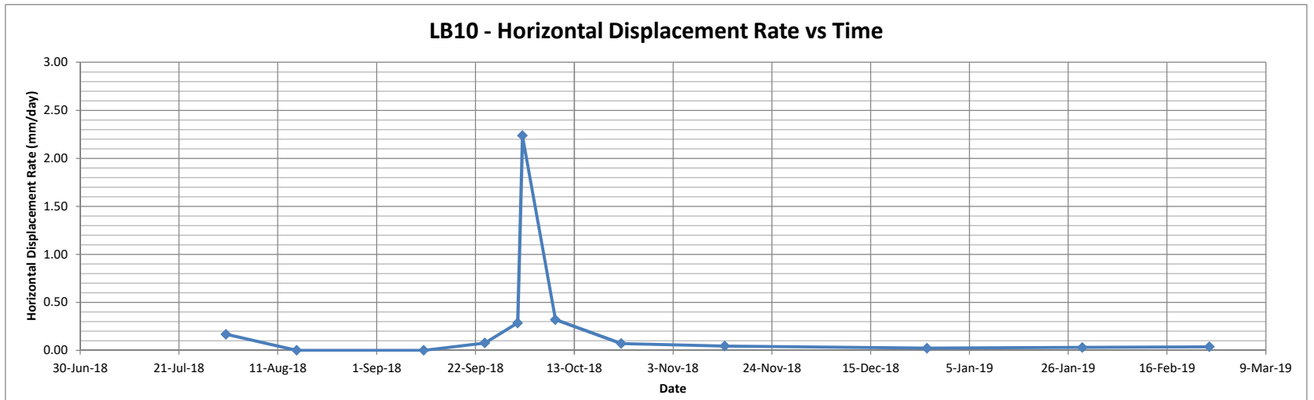
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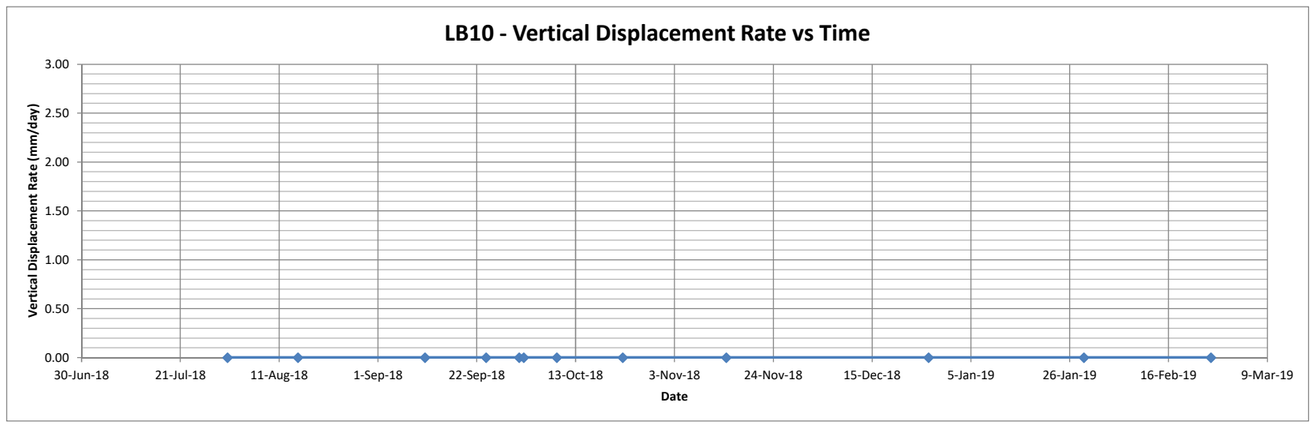
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FIG No. VIII-11

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APPENDIX IX

Map of Water Quality Monitoring Points

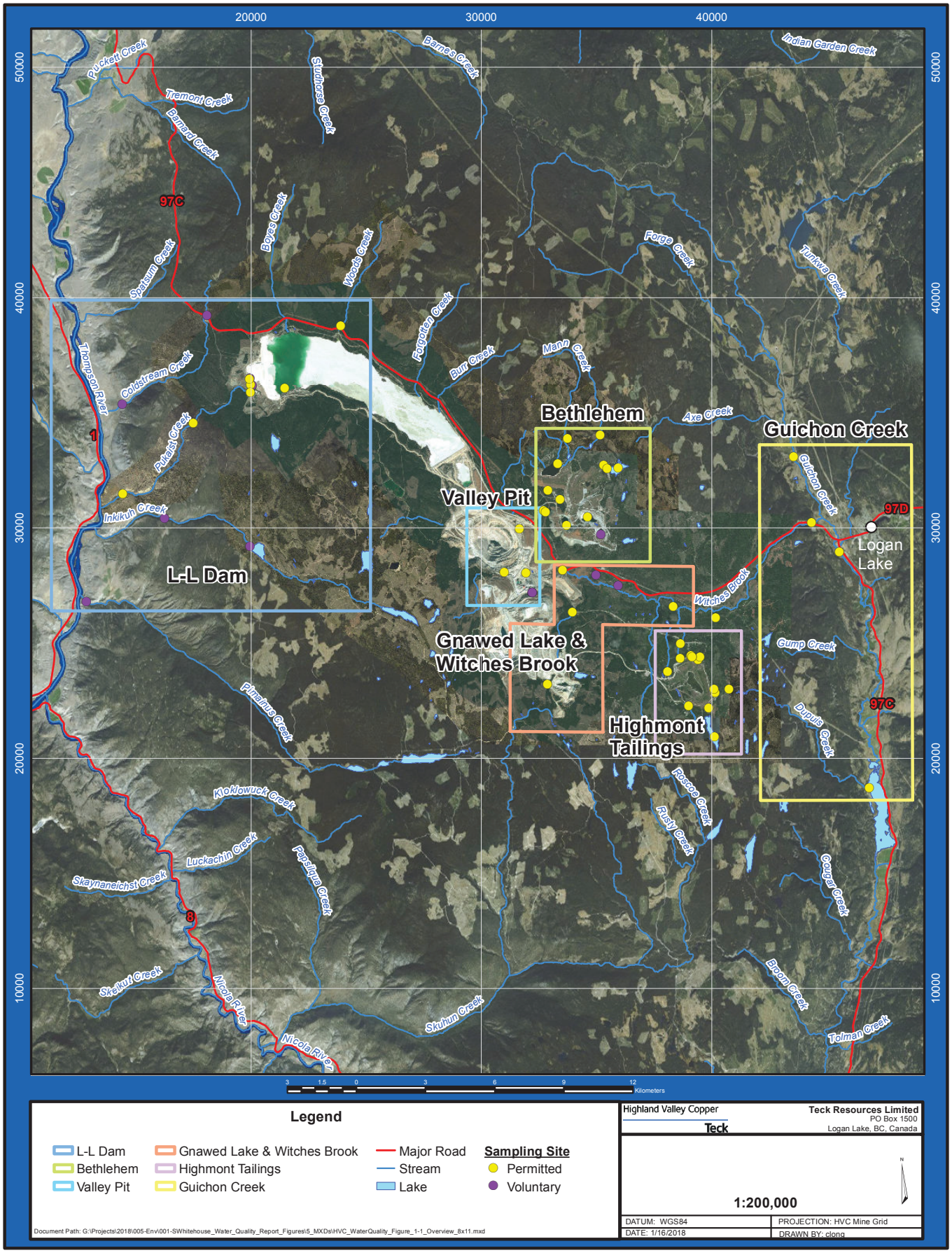


Figure E-1 Water Quality Monitoring Sites, Highland Valley Copper, 2018

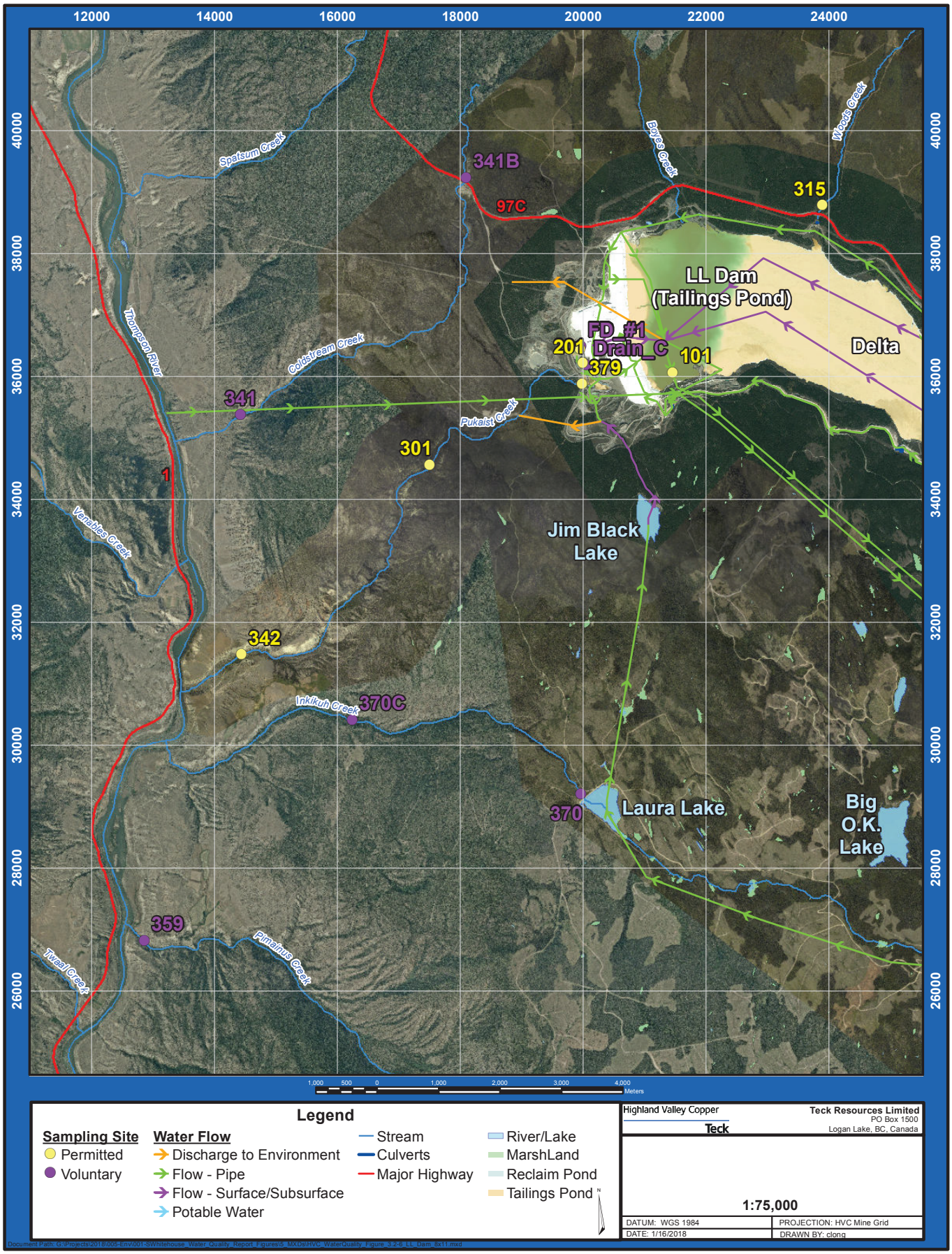


Figure 3.2-5 Water Quality Monitoring Sites in the LL Dam/Thompson Valley Area, Highland Valley Copper, 2018

APPENDIX X

DSR Recommendations and Status Update

Table X-1 2017 Highland TSF Dam Safety Update Recommendation / Response Summary

ID	Priority	Comment	Topic	Lead	*Response - Nov.2018*	Response - February 2019	Scheduled Completion	Current Status (*Feb.2019 Status*)
TSF-2017-01	*4*	*'The DSR is a snapshot at a particular point in time of the assessment of whether the dam is being reasonably safely operated using the current state of practice for dam safety analysis....if it is clear during the review process, that imminent changes are to be made, or are in the process of being made, to the dam or the dam's environment, the QPE should assess the impact of these changing conditions on the safe operation of the dam in the immediate future and document these impacts in the DSR report' (EGBC, 2016).* *We understand that there will be a site characterization update in 2018 which may trigger design changes. If these changes are significant, there should be an update of this DSR or independent review of the updated 2018 design to reflect the changes in dam design.*	*Update*	*THVCP*	*DSR to be scheduled for 2020. On THVCP Planning documents.*		*-*	*Closed*
TSF-2017-02	4	We noted that several reports were not finalized (AMEC, 2012) (AMEC, 2014) (AMEC, 2015) (KCB, 2016) (KCB, 2017) (KCB, 2017). We recommend reports are finalized in line with best management practice.	Documentation	THVCP	*Commission reports to be finalized.*	This is in progress, some of the draft reports have been finalized or superseded (e.g. foundation characterization, seismic hazard). Other reports will be either finalized or superseded later in 2019 as part of design update.	Q4 2018	In Progress
TSF-2017-03	*4*	*LiDAR surveys are collected every six months, but we understand that successive surveys are not compared. We recommend production of incremental change maps and cumulative change maps after every survey. This is an economical way to:* *· Supplement the existing observation and surveillance program* *· Highlight areas of significant surface movement (within limits of resolution), such as toe bulges etc.* *· Confirm wind sand loss and migration of the toe berms at L-L dam is not significant.* *· Highlight areas of significant settlement at H-H dam* *· Aid interpretation of settlement vs. movement at H-H Dam.* *· Confirm the waste dumps adjacent to 24 Mile Lake are not demonstrating movement.*	*Surveillance*	*THVCP*	*Compile incremental survey*	*-*		*Closed*
TSF-2017-04	4	The data review has found that there is a significant quantity of design reports, construction reports and memorandums since 2010. This does not include data from the early 1970s'. For example, we have found several iterations and design updates, on discrete dam sections, presented in a range of reports and appendices with somewhat unrelated titles, whilst the current design is from 2010. Given the nature of large TSF's, where design is updated in sections according to priority and design issues, we recommend that THVCP complete a summary that lists the latest reports, design basis, stability, seepage, geological characterization and failure modes for each section. This could be included within the OMS manual and updated annually.	Documentation	KCB	*Ongoing Design Update report will be a consolidated review of L-L Dam and H-H Dam designs.* *KCB / THVCP to discuss preparation of document register for Highland TSF.*	No change, still planned as part of design update.	Q2, 2019	In Progress
TSF-2017-05	4	We understand that significant geotechnical investigation and testing has been undertaken in 2017. Any subsequent update to parameters based on this new investigation should be clearly documented and checked against the current 2010 design to determine if design updates are required.	Design	KCB	*Design Update report will incorporate all recently collected data (investigations, performance, etc.) into design analyses.*	Latest parameters, interpretations and foundation characterization for L-L Dam were issued in 2018 Permit Report. Additional information and H-H Dam interpretation will be included in design update.	H-H Dam Q2, 2019	H-H Dam In Progress L-L Dam Completed in Q4, 2018
TSF-2017-06	3	Our screening review of the geology model has identified localized discrepancies between cross-sections and longitudinal-sections. It is recommended that the geological boundaries defined in each design section be confirmed by considering the 3D geology.	Characterization	KCB	*"Final" cross sections are being prepared that incorporate all 2017/2018 site investigations and discrepancies from interim updates will be checked.* *These are not considered significant discrepancies that have a significant influence on design.*	Scope planned for 2019 (extend cross sections, prepare fence diagrams, add new data points)	Q3, 2019	Planned
TSF-2017-07	3	Further testing of controlling foundation units such as weak rock units and different tailings streams (including slimes) and dam fill materials using appropriate techniques (such as ring shears, relationship between sample size and strain softening etc.). is recommended to better characterize the behavior of these materials.	Characterization	KCB	*2017/2018 drilling and laboratory programs are complete. Revision to L-L Dam foundation characterization letter and preparation of a similar document for the H-H Dam foundation are in progress to support Design Update.* *No additional shear strength testing completed on cycloned sand fill as part of recent programs, not a controlling unit for dam stability. Has been flagged as part of 2040 Project FS study (if it progresses to that stage) to assess behaviour under high confinement stress (>200 m dam height).*	No change in plan to document all work. Recent comments on laboratory testing programs: - Additional cyclic simple shear tests completed on L-L Dam glaciolacustrine samples (conisdered in dynamic FLAC model) - Portion of the cycloned sand in the VBB (~2 m) has become saturated in response to 2018 construction. This observation drives potential for laboratory testing to define behaviour under high confinement as part of current LOM design.	Q2, 2019	In Progress
TSF-2017-08	*3*	*The identification of piezometers that are found to be newly 'plugged' should trigger a review of surrounding piezometers and inclinometers (level 1 threshold) to eliminate the possibility that the plugging is due to movement. Consideration should be given to cleaning out or replacing instruments found to be plugged.*	*Surveillance*	*KCB*	*Updated but not considered necessary for surveillance program because standpipe piezometers are not relied upon on for Observational Method or Emergency Response measures. There are nearby vibrating-wire-piezometers instruments which are connect to remote monitoring system, could also be captured by inclinometers if piezometer is damaged by horizontal movements.*	*-*	*-*	*Closed*
TSF-2017-09	*3*	*The OMS manual should be updated to incorporate new instrumentation and associated thresholds related to the design when available.*	*Documentation*	*KCB*	*2018 OMS Manual has been issued.*	*-*	*-*	*Closed*
TSF-2017-10	*3*	*Based on the longitudinal upstream cracking observed historically in the H-H dam and the potential for cracking of the core to increase the phreatic surface in the downstream shell, we recommend that a minimum PI in the till core is considered in the specification.*	*Construction*	*KCB*	*Will be considered as part of Design Update. Current practice is to identify Glacial Till suitable for dam fill are characterized in the borrow which includes review of plasticity.*	*Work done in Q1, 2019 to better define borrow areas and estimate material quantities. Glacial Till remains consistent and inclusion of PI into specification not required.*	*-*	*Closed*
TSF-2017-11	3	We recommend the emergency procedures following fire or fire evacuation and their impact on the observation and surveillance program are considered within the OMS manual,	Documentation	THVCP	*Under consideration.*	THVCP is located in a region that can experience wildfire hazards throughout the year. Contingency planning around wildfires will be incorporated into the surveillance portion of the 2019 OMS update.	Q4, 2019	Start Q2, 2019
TSF-2017-12	4	Stantec routine check of stability at each dam indicated that the stability was not likely sensitive to the undrained strength ratio adopted for the upstream tailings. Due to uncertainties in the value of the undrained strength ratio, we recommend that sensitivity is undertaken for other design sections when the design is updated. This will highlight whether in-situ investigations are valuable. be used to better characterize the engineering properties of the tailings	Characterization	KCB	*2018 drilling program included CPTs through tailings beach in front of H-H Dam to support Design Update.* *As noted by DSR, the dam designs are not governed by assumed tailings strengths. Design Update will include sensitivity analyses to demonstrate this.*	This was also discussed in 2018 Permit Report and will be discussed in design update.	Q2, 2019	In Progress
LL-2017-01	3	We recommend further investigation and stability modeling of the zone at around St. 3+500 m which may contain weak rock horizons layers is located between design sections and is understood to contain a basal flow unit overlain by weathered basalt. The basal flow unit was described as very closely sheared, highly to extremely weathered and weak. The overlying basalt rock mass was described as closely to extremely closely-spaced jointed. The consideration of a failure along the basal flow unit should be considered. The geology of the 'rock knoll' is not delineated and further investigation and modelling is recommended to understand this zone better.	Design	KCB	*Need to add an additional analyses section will be reviewed as part of Design Update. Based on reviews completed to date, the need for an additional section at Sta. 3+500 is unclear. Recent drilling along toe and crest in this area indicate bedrock is at depth (>40 m) except at discrete locations in older drill holes. Stability in the area is governed by the continuous (inferred) shallow glaciolacustrine deposit between Sta. 3+300 and 3+800.*	No change.	Q2, 2019	Start in Q3, 2018
LL-2017-02	4	The GLU at the north abutment, described as 'rising in steps' (KCB, 2016) and the geological interpretation (KCB, 2016) should be reviewed.	Characterization	KCB	*Characterization of discontinuous glaciolacustrine in the North Abutment area is consistent with Highland Valley geologic history and has been reviewed by Dr. John Clague. Is being reviewed as part of L-L Dam characterization which is in progress and updates will be made, as appropriate.*	No change made to characterization. 2040 FS drilling program will include additional information beyond current LOM footprint which will be incorporated into characterization when available.	Q2, 2019	In Progress
LL-2017-03	3	We recommend additional investigation and laboratory testing to confirm the strength parameters and the extent of bedrock under the NBB and VBBE as the stability is sensitive to the extent and strength of this layer; however, there has been limited investigation or advanced strength testing on the weak mudstone. The investigations should confirm the lateral constraints of the weak mudstone, any overlying constraining stronger volcanic units and the its geotechnical behavior.	Characterization	KCB	*2017/2018 drilling and laboratory programs are complete. Revision to L-L Dam foundation characterization letter is in progress to support Design Update. This included drilling and laboratory testing of mudstone and other bedrock units.*	Update to interpretation presented at TRB Meeting No. 18 (Nov.2018). Work and modelling has progressed, scheduled to be discussed at August 2019 TRB meeting as part of design update.	Q2, 2019	In Progress
LL-2017-04	*3*	*Foundation conditions in the northern portion of the VBBE are understood to be similar to that of the NBB; however, the berm is notably smaller at this location. The VBBE slope stability analyses (KCB, 2017c) indicate that the proposed ultimate dam design configuration at this location does not comply with the minimum FOS criteria for all assumed elevations of the mudstone residual zone. Following the completion of LL-2017-03, we recommend the VBBE design is reassessed to evaluate if any modifications are required to achieve the design criteria FOS. We recommend future construction considers the potential for residual strengths within this material.*	*Design*	*KCB*	*Geology beneath the VBBE has been characterized as discontinuous glaciolacustrine on the south side with potential for continuation of some mudstone layers on the north side. The slope stability was checked based on the latest geology in the Observational Implementation report for both scenarios to check adequate FOS were acheived. Additional drilling was completed in the area in 2018 which is being incorporated into the ongoing characterization and Design Update analyses.*	*VBBE geology was discussed and design analyses using updated geology reported in the 2018 Permit report. Will also be discussed in design update but issue considered closed.*	*Q1, 2019*	*Closed*
LL-2017-05	*3*	*The impact and likelihood of failure of the Jim Black Dam on the L-L dam should be reviewed. This issue was raised in the Risk Assessment Report (AMEC, 2015) but we understand that this not been closed out yet.*	*Risk*	*KCB*	*AMEC completed an assessment of L-L Dam toe erosion potential (AMEC 2016) which estimated a peak flood level of El. 1106 m resulting from a Jim Black Lake breach during a probable maximum flood (PMF). 2018 construction at the L-L Dam included decommissioning of Slimes Pond 1 and Seepage Pond 1 and construction of a non-structural (i.e. not considered is structural stability) sand and gravel toe bench (minimum 10 m wide) to El. 1108 m along the toe of the L-L Dam in the potential flood zone. Natural ground in this area is approximately El. 1104 m to 1105 m, resulting in potentially 1 m to 2 m of flow against the sand and gravel toe bench. This would result in some erosion of the sand and gravel and potentially the dam toe but which would require maintenance but not sufficient to trigger a concern regarding failure of the L-L Dam.*	*-*	*-*	*Closed*
LL-2017-06	3	We recommend the development of an action plan to install seepage weirs by dam sector and that this should include the determination of thresholds for seepage flows	Surveillance	THVCP	*Due to the presence of a blanket drain beneath the downstream dam shell and the slope of the natrual ground towards the valley base, it is not practical to separate seepage from each dam sector.* *Following 2018 construction the ultimate toe of the dam will be established along most of the dam length and longer term seepage monitoring weirs can be collected to measure flows which daylight from the dam shell at select locations.*	Seepage weirs are an important tool in monitoring water conditions. Where appropriate, weirs will be included in the long term monitoring plan in both interim and permanent locations.	Ongoing	In Progress
LL-2017-07	2	Given the core geometry and known deformations at the dam we recommend an evaluation of some sensitivity studies on the impact of core cracking and dam stability	Design	KCB	*KCB has already recognized the potential for core cracking given its narrow width, as discussed at previous TRB meetings and are planning to undertake sensitivity analyses in Design Update to assess impact. Thresholds for dam fill and drain materials are in place which would notify THVCP and KCB if there were sudden changes in the piezometric levels in the dam (not related to hydraulic placement).*	Design update analyses includes sensitivity analyses for elevated piezometric levels in downstream dam shell. Also, discussion regarding core performance will be included in design update report based on deformation models (static / dynamic).	Q2, 2019	In Progress
LL-2017-08	*3*	*We recommend future construction to the design grades to prevent a repeat of the over-steepening of L-L Dam.*	*Construction*	*KCB*	*Practice has been adopted.* *Steepened slopes at the L-L Dam were build to support core raises as downstream cycloned sand had not been raised high enough to support the core at the ultimate design slope. Stability of existing condition has been reviewed by KCB and downstream sand will be caught up with the core in 2019.*	*-*	*-*	*Closed*
LL-2017-09	3	A 20 % reduction in the L-GLU strengths was applied for post-earthquake loading conditions in the VBBE stability analyses, presumably to account for cyclic softening. There is no discussion regarding the rationale for not applying this to other potentially susceptible units such as the till core. This should be further evaluated and information to justify this assumption should be presented. If this assumption is not justified, the analyses should be updated to consider cyclic softening in other susceptible units.	Design	KCB	*Justification for post-earthquake shear strength parameters will be expanded in Design Update report based on additional laboratory testing completed in 2018. Note that the dam core zone is constructed of Glacial Till and not Glaciolacustrine material.*	Post-earthquake shear strengths at L-L Dam were described and incorporated into design analyses reported in the 2018 Permit report. However, discussion of glaciolacustrine post-earthquake shear strengths will be discussed further in design update based on cyclic laboratory testing.	Q2, 2019	In Progress
HH-2017-1	3	We recommend a review of as-built records and assessment of the range of as-built filter widths and how these relate to ongoing design.	Construction	KCB	*Update of construction history was completed as part of H-H Dam performance review. Demonstrating core can be removed from H-H Dam and revisions to filter designs will be developed as part of Design Update.*	No change.	Q2, 2019	In Progress
HH-2017-2	*4*	*We recommend that the design parameters of the rockfill are calibrated against the performance of the waste dumps at the mine as these are composed of similar fill rockfill and heights, and that a shear-normal curve adopted for the rockfill*	*Design*	*KCB*	*As majority of downstream fill in H-H Dam has a significant sand and gravel component rather than coarse rockfill. As the internal static shear strength of the downstream rockfill influences local bench and sloughing failures only (i.e. doesn't govern overall dam stability) this approach is not planned to be adopted.*	*-*	*-*	*Closed*
HH-2017-3	3	We recommend that consideration is given to either to the relocation, continued monitoring or additional support of the lock-block; and that the thresholds are included in the OMS manual. Movement of the wall could trigger failure of the tailings pipes or instability.	Design	KCB	*The lock-block wall cannot be relocated as it is necessary to provide adequate setback of the dam toe from the H-H Pumphouse. As part of Design Update, a modified dam cross section in this area is being developed for ultimate height that takes the lock-block wall into consideration and doesn't require any further step-outs of the dam toe.*	No change.	Q2, 2019	In Progress
HH-2017-4	*3*	*We recommend the installation of instruments to understand the sensitivity of the phreatic surface upstream of the core and to understand deformation and settlement within the dam.*	*Surveillance*	*KCB*	*Instruments to achieve these functions were installed in 2017/2018. No further action planned.*	*-*	*-*	*Closed*
HH-2017-5	*4*	*There is a disconnect between documentation of the 2017 monitoring systems and the observational approach which we recommend should be rectified.*	*Documentation*	*KCB*	*2018 OMS supersedes previous versions and addresses recommendation.*	*-*	*-*	*Closed*
HH-2017-6	3	The suitability of the interface between the core and the adjacent structural fill in the lower portion of the H-H Dam should be demonstrated from a core particle retention standpoint.	Design	KCB	*Filter review and continued need for the core zone are included in the ongoing Design Update.* *The lack of engineered filter between the core zone and downstream general fill above the starter dam (~El. 1195 m) to ~El. 1255 m is known. No indicators of material piping into the downstream shell have been noted during dam operation (e.g. sinkholes, sudden changes in piezometric surfaces)*	No change.	Q2, 2019	In Progress
HH-2017-7	3	We recommend the construction specifications include a requirement that the filter materials be non-plastic, as the use of plastic filter materials represents a dam safety risk as such materials may allow for a crack to be maintained and piping to initiate. This risk is further compounded by the settlements observed at the H-H Dam to date. A review of construction testing data should be performed to evaluate if plastic filter material has been placed at the dam. If this material has been placed, the potential for this material to maintain a crack should be assessed.	Construction	KCB	*The H-H Dam filter (SG2) is sourced from Bethsaida Sand from the open pit which has been characterized as non-plastic. Summary will be compiled for Design Review report and the need to change the specification or additional testing (e.g. sand castle) will be considered pending outcomes of Design Update core assessment.*	No change.	Q2, 2019	In Progress
HH-2017-9	3	The SGM and geotechnical characterization of the H-H Dam is not as understood compared to the L-L Dam. We understand there is already a plan for further investigation and we recommend this plan is executed.	Characterization	KCB	*A foundation characterization document, similar to what has been prepared for L-L Dam, is being developed which will include geology sections and foundation stratigraphy and characterization of units. This was deferred until after the 2017/2018 drilling programs when significant investigations were completed at H-H Dam.*	No change.	Q2, 2019	In Progress
H-H-2017-10	3	Based on relatively large deformations within the rockfill at H-H dam and the historical longitudinal upstream cracking observed in the H-H dam, we recommend an evaluation of the settlement potential of the rockfill and its associated impact on the core.	Design	KCB	*Current interpretation is that horizontal movements measured by inclinometers in the upper section of the dam and cracking which has been observed at surface are caused by settlement of downstream fill. Sondex settlement monitoring has been installed to provide monitoring data to support that interpretation which will be summarized in Design Update report.*	No change.	Q2, 2019	In Progress