Valentine Gold Project: Federal Information Requests

Responses to IR-08 to IR-26

MARATHON GOLD

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LIST OF APPENDICES

RESPONSE TO IR-08

ID:	**IR-08**
Expert Department or Group:	NRCan-01
Guideline Reference:	Section 7.1 Section 7.1.5 Project Setting and Baseline Conditions – Groundwater and Surface Water
EIS Reference:	Baseline Study Appendices 3, Attachment 3-D, Hydrogeology Baseline Report, Section 4.4
Context and Rationale:	The EIS Guidelines state that the EIS will present information in sufficient detail to enable the identification of how the project could affect the Valued Components and the analysis of those effects. In particular, Section 7.1.5 require temporal changes in groundwater flow (e.g., seasonal and long term changes in water levels). Adequate groundwater level information, both in terms of spatial and temporal distribution, is required to understand groundwater flow quantity and timing in terms of seepage towards, or loss of flow from, surface water bodies. These changes are a component of the assessment of changes to fish and fish habitat and the aquatic species. A complete seasonal cycle of groundwater elevation change was only monitored in open exploration holes, which may dampen temporal variability. Monitoring from October to March in hydrogeological monitoring wells resulted in 3 m of seasonal variability in the absence of potential summer seasonal lows. Additionally, groundwater level information is spatially limited to the area within, and between the open pits. There is very limited information down gradient of the waste rock storage facilities and tailings management facility (TMF).
Information Request:	a. Provide groundwater elevation data from hydrogeological monitoring wells for a complete 12-month period. Incorporate this information into the conceptual model of groundwater flow, and the assessment of impacts from the project. b. Provide information on groundwater elevation down gradient of the waste rock storage facilities, and the Tailings Management Facility.
Response:	a. Groundwater monitoring has continued at the mine site at three of the monitoring locations presented in the EIS - MW1 (located north of the site), MW4 (located downstream of the Tailings Management Facility), and MW5 (located in the footprint of the Leprechaun Waste Rock Pile), as presented in Figure IR-08-1 (in Appendix IR-08.A). The year-long water level hydrographs show that groundwater levels were typically lower during the winter months and in the mid- to late-summer, corresponding to periods with relatively lower infiltration rates. The highest groundwater levels were recorded during the spring

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	corresponding to the spring freshet, and during the fall rainy period. Seasonal fluctuations in groundwater levels ranged from 0.6 m in MW1 to 1.12 m in MW5. Although the averages are slightly different than the values used in the model calibration, the calibration statistics from the model are slightly improved, and do not require the conceptual model, model calibration, or effects assessment to be updated. b. Additional groundwater monitoring has been conducted at the mine site that includes the installation of new wells to support ongoing design work for the mine components, as shown on Figure IR-08-1 (in Appendix IR-08.A). The water level data associated with these locations is shown on Table IR-08-1 (in Appendix IR-08.A). The majority of the wells are located inside the footprints of the project components. Additional monitoring wells will be installed downgradient of the waste rock piles and Tailings Management Facility prior to the development of the Project to characterize the water quality and water levels downgradient of the Project.
Appendix:	Appendix IR-08.A

RESPONSE TO IR-09

ID:	**IR-09**
Expert Department or Group:	NRCan-02 MW-48
Guideline Reference:	7.1.5 Project Setting and Baseline Conditions – Groundwater and Surface Water
EIS Reference:	Baseline Study Appendices 3, Attachment 3-D, Hydrogeology Baseline Report, Sections 4.2,4.3, 4.4 Chapter 2, Appendix 2C Prefeasibility Geotechnical Report, Sections 5.6, 7.2, and7.4
Context and Rationale:	The EIS Guidelines require the inclusion of a delineation and characterization of groundwater - surface water interactions. Natural Resources Canada has noted that in the EIS the Valentine Lake Thrust Fault, and other mapped faults fracture and shear zones are not well characterized. However, complimentary data indicates the potential for the fault zone to be a zone of increased hydraulic conductivity (e.g., lower rock quality designation (Section 4.2)), or a structural control on groundwater flow direction (the presence of artesian conditions in bedrock (Section 4.4)). One packer test was completed within the fault zone (Baseline Report Section 4.3) and it indicated that the fault zone has lower rock quality and a higher hydraulic conductivity (Appendix 2C, Prefeasibility Geotechnical Report, Section 5.6). During pit dewatering, faulting that has enhanced hydraulic conductivity may reduce water levels within connected waterbodies impacting fish and fish habitat. Conversely, if there are clay gouge along fault planes, faulting may lower hydraulic conductivity and may direct drawdown related to open pit dewatering much further in one direction relative to another. Both fault types may influence the degree to which open pit dewatering influences groundwater – surface water interactions.
Information Request:	a. Provide more information on the results of the packer test completed within the fault and the relationship between rock quality and hydraulic conductivity within the context of the conceptual model of groundwater flow. b. Discuss the location and orientation of mapped fault, fracture and shear zones including the potential for these zones to hydraulically connect the open pits to surface water features. c. In the numerical assessment of the fault, provide maps indicating the drawdown and seepage flow paths under the various fault scenarios for both the water table and at depth within the bedrock.
Response:	a. Packer testing of faults has been completed by Gemtec for Terrane Geoscience Inc. (Terrane 2020, 2021). The hydraulic conductivity for

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	the Valentine Lake thrust fault ranged from 2.5×10^{-9} m/s to 6.7×10^{-6} m/s, with a geometric mean of 7.0×10^{-8} m/s at the Marathon deposit. Similar results were also obtained for the other faults local to the Marathon deposit. A single packer test was completed for the Valentine Lake thrust fault, with a hydraulic conductivity value of 1.4×10^{-9} m/s; it is noted that this value is approximately one order of magnitude lower than that determined at the Marathon deposit. The geometric mean for the other faults local to the Leprechaun deposit was 4.8×10^{-8} m/s. Overall, the hydraulic conductivities determined for the Marathon and Leprechaun deposit faults (including the Valentine Lake thrust fault) were within the range of values for the various rock types, and were not found to be hydraulically distinct from the surrounding rock mass. This continues to support the assumption the faults in the proposed open pits are not expected to be substantial preferred pathways for groundwater flow, or constitute problem areas for seepage control. b. Maps showing local and regional faults within the vicinity of the faults were prepared by Terrane, and are presented in Terrane (2021) Figures 9 and 10 (attached). The structural geology information for these faults is presented in Terrane (2021) Tables 13 and 15 (attached). As shown, the regionally extensive Valentine Lake Thrust Fault is sub-vertical, dipping from 80º in the Marathon deposit, to 70.1º in the Leprechaun deposit. The faults are dominantly oriented along a east-northeast direction (strike between 230º to 250º). As discussed in the response to part a), the hydraulic conductivities determined for the Marathon and Leprechaun deposit faults (including the Valentine Lake thrust fault) were within the range of values for the various rock types, and were not found to be hydraulically distinct from the surrounding rock mass. This continues to support the assumption the faults in the proposed open pits are not expected to be substantial preferred pathways for groundwater flow, or constitute problem areas for seepage control. c. Maps showing the drawdown and particle tracks showing potential seepage pathways for the fault scenarios are included in the response to IR-13.
Appendix:	None

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FIGURE 9 - Terrane 2020 Fault Model
Marathon Deposit

Scale: 1:7000	Date: Jan.07, 2021
Drawn: ACH	Checked: AG
Approved: TLG	Figure 9

LEGEND

🟦	Mafic Intrusive Domain[1.]
🟪	Quartz-Eye Porphyry Domain[1.]
🟫	Conglomerate Domain[1.]
– –	Fault - High Confidence[2.]
– –	Fault - Medium Confidence[2.]
– –	Fault - Low Confidence[2.]
—	10 m Topographic Contours
☐	Marathon Pit Outline (December 2020)

0 125 250 Meters

TERRANE
GEOSCIENCE INC.
www.terranegeoscience.com

Notes
1) Lithology polygons provided by Marathon
2) All faults from 2020 Terrane Modelling
3) NAD83 UTM Z21N

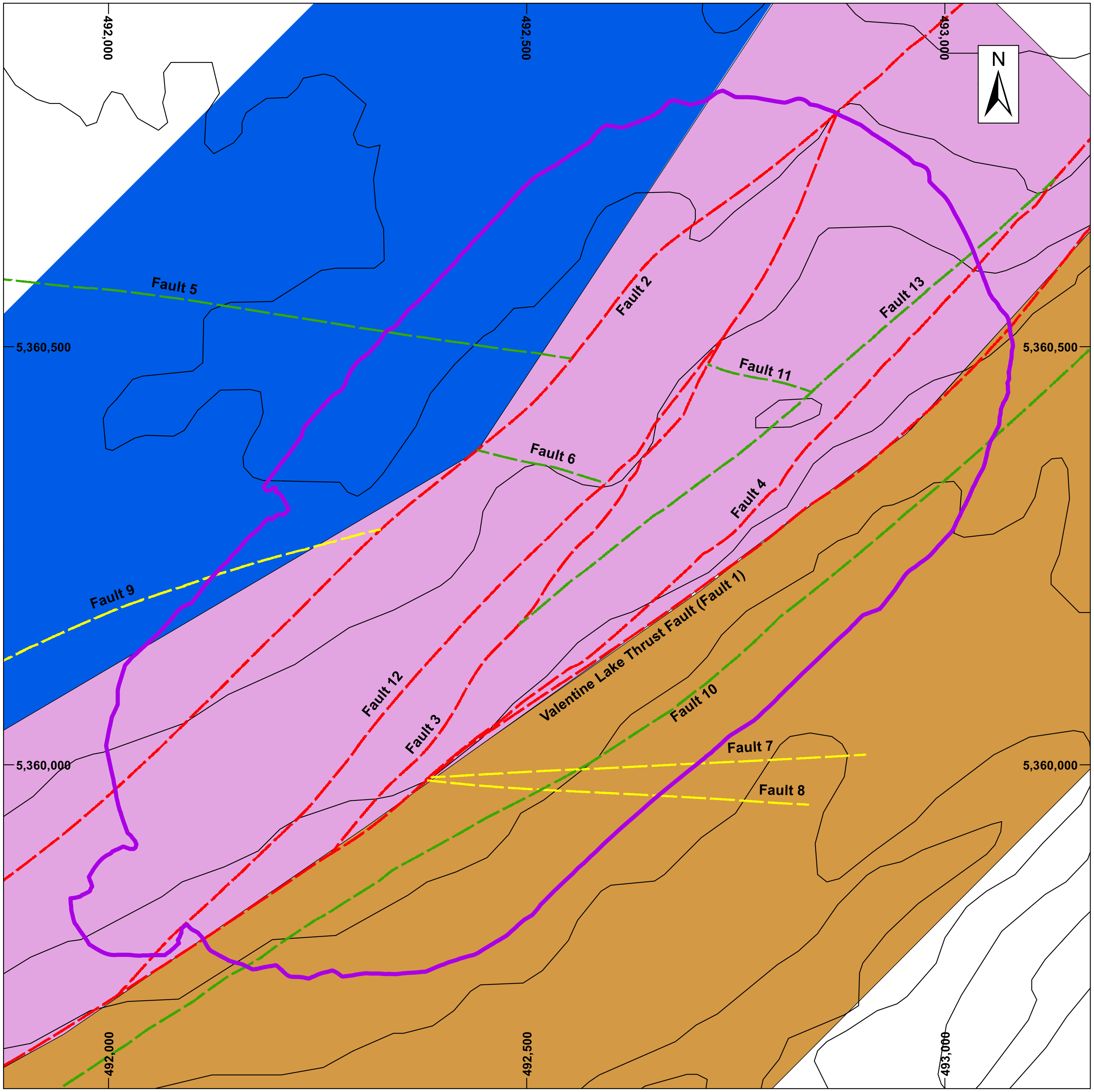

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FIGURE 10 - Terrane 2020 Fault Model
Leprechaun Deposit

Scale: 1:7,500	Date: Jan.07, 2021
Drawn: ACH	Checked: AG
Approved: TLG	Figure 10

LEGEND

🟦	Trondhjemite Domain
🟧	Conglomerate Domain
- - -	Fault - High Confidence [1.]
- - -	Fault - Medium Confidence [1.]
- - -	Fault - Low Confidence [1.]
—	10 m Topographic Contours
☐	Leprechaun Pit Outline (December 2020)

0 150 300 Meters

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Notes
1) All faults from 2020 Terrane Modelling
2) NAD83 UTM Z21N

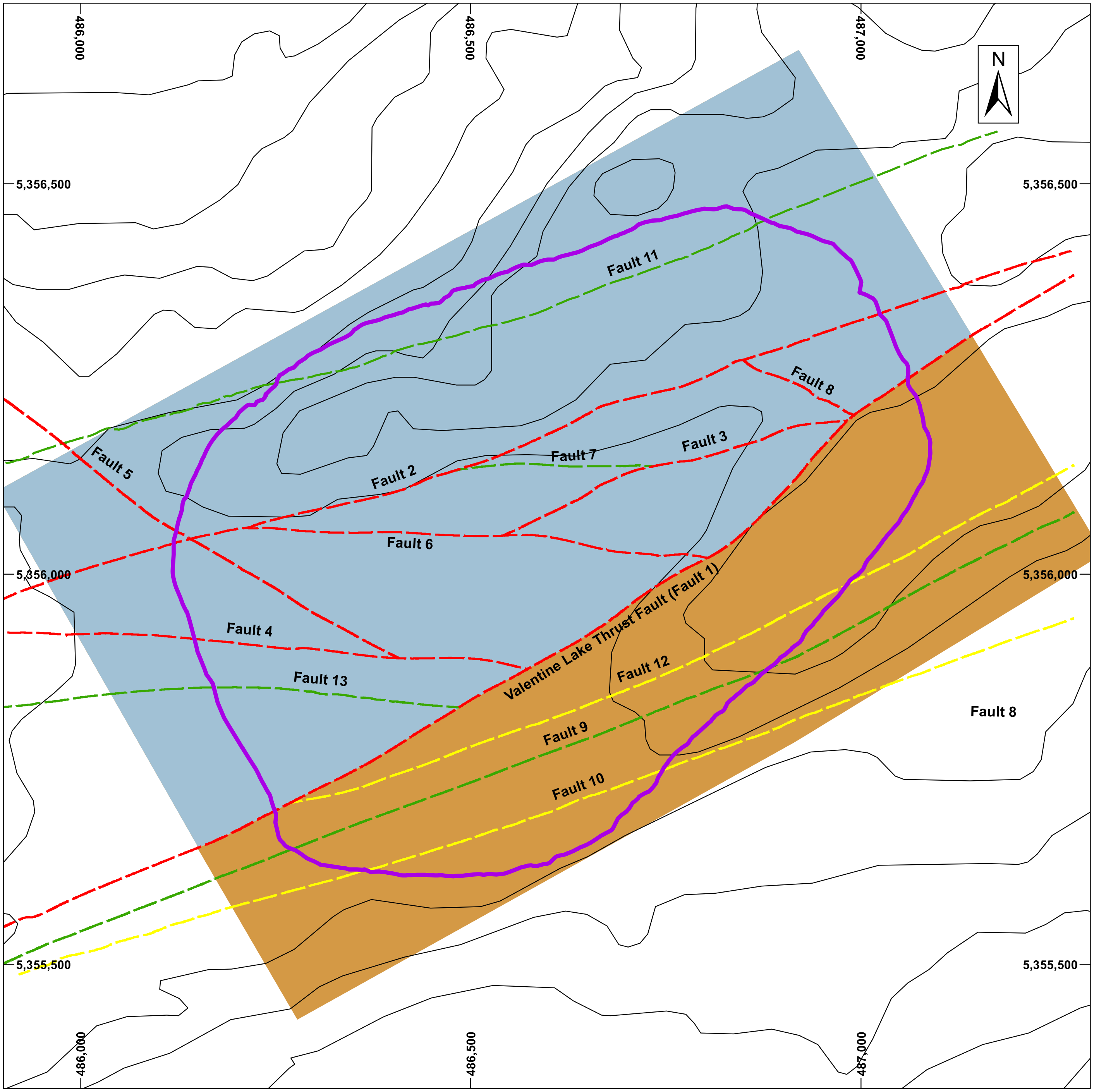

Table 13 - Marathon Modelled Fault Summary

Fault ID	Strike (°)[1]	Dip (°)[2]	Topo. Lineament[3]	Magnetic Lineament[3]	No. DDH Logged Faults[4]	No. DDH Intercepts RQD < 50%[5]	Televiewer /Orientated Core[6]	Observed in Surface Mapping[7]	Confidence Score	Confidence[8]
Fault 1	233.6	80	1	1	5	5	3	1	16	High
Fault 2	226.4	77.1	1	1	2	5	3	0	12	High
Fault 3	216.8	79.1	0	1	5	5	4	1	16	High
Fault 4	228.8	75.1	1	1	3	5	3	1	14	High
Fault 5	277.1	66.8	1	0	1	1	2	0	5	Medium
Fault 6	283.9	77.1	0	1	0	3	3	0	7	Medium
Fault 7	265.6	76.5	1	0	0	2	1	0	4	Low
Fault 8	273.6	77.4	0	0	0	1	2	0	3	Low
Fault 9	254.2	41.9	1	0	0	0	1	0	2	Low
Fault 10	232.5	85.7	1	1	0	1	2	0	5	Medium
Fault 11	287.5	69.6	0	1	0	2	2	0	5	Medium
Fault 12	222.6	75.9	0	1	0	5	4	0	10	High
Fault 13	230.6	77.1	0	1	0	5	1	0	7	Medium

Notes:

1. Strike using right-hand rule, reported strike is the mean strike from stereonet analysis of each faults modelled vertices.
2. Dip is the mean dip from stereonet analysis of each faults modelled vertices.
3. Does a topographic or magnetic geophysical lineament exist, yes (1) or no (0).
4. Number of logged structures used to model fault that are coincide with logged fault zone (>0.25 m), lost core zones, and/or conglomerate-quartz eye porphyry contact (Fault 1 – Valentine Lake thrust fault). Score ranges from 0-5, score capped at 5.
5. Number of RQD runs used to model fault that are coincident with modelled fault with RQD<50%. Score ranges from 0-5, score capped at 5.
6. Number of times fault is observed in televiewer and/or oriented core. Score ranges from 0-3, score capped at 3.
7. Observed in surface mapping from S. Kruse, 2020.
8. Low (0-4), Medium (5-9), High (>10).

Table 15 - Leprechaun Modelled Fault Summary

Fault ID	Strike (°)[1.]	Dip (°)[2.]	Weak Topo. Lineament[3.]	Strong Topo. Lineament[3.]	No. DDH Logged Faults[4.]	No. DDH Intercepts RQD < 50%[5.]	Televiewer /Orientated Core[6.]	Observed in Surface Mapping[7.]	Confidence Score	Confidence[8.]
Fault 1	236.5	70.1	1	1	5	5	2	1	15	High
Fault 2	250.7	56.7	1	1	5	5	3	1	16	High
Fault 3	250	57.1	1	1	3	5	2	1	13	High
Fault 4	275.9	54.5	1	1	5	5	3	1	16	High
Fault 5	299.7	52.6	1	1	5	5	1	1	14	High
Fault 6	274.8	52.4	1	1	4	5	0	1	12	High
Fault 7	269	54.6	1	0	2	5	0	1	9	Medium
Fault 8	294.2	54.3	1	0	1	5	3	0	10	High
Fault 9	248.6	57.8	1	1	0	2	2	0	6	Medium
Fault 10	251	53.3	1	0	0	1	2	0	4	Low
Fault 11	250.2	55	1	1	0	2	0	1	5	Medium
Fault 12	248.1	64.3	0	0	0	0	3	0	3	Low
Fault 13	275.7	55.1	1	1	0	4	2	0	8	Medium

Notes:

1. Strike using right-hand rule, reported strike is the mean strike from stereonet analysis of each faults modelled vertices.
2. Dip is the mean dip from stereonet analysis of each faults modelled vertices.
3. Does a topographic lineament exist, if so, is it weak or very well defined, strong, yes (1) or no (0).
4. Number of logged structures used to model fault that are coincide with logged fault zone (>0.25 m), lost core zones, and/or conglomerate-quartz eye porphyry contact (Fault 1 – Valentine Lake thrust fault). Score ranges from 0-5, score capped at 5.
5. Number of RQD runs used to model fault that are coincident with modelled fault with RQD<50%. Score ranges from 0-5, score capped at 5.
6. Number of times fault is observed in televiewer and/or oriented core. Score ranges from 0-3, score capped at 3.
7. Observed in field mapping from S. Kruse, 2020.
8. Low (0-4), Medium (5-9), High (>10).

RESPONSE TO IR-10

ID:	**IR-10**
Expert Department or Group:	NRCan-03
Guideline Reference:	7.1.5 Project Setting and Baseline Conditions – Groundwater and Surface Water
EIS Reference:	Baseline Study Appendices 3, Attachment 3-D, Hydrogeology Baseline Report, Sections 2.3, Chapter 6, Appendix 6A, Sections 2.2.1, 3.3, and 4.1(Table 4-1).
Context and Rationale:	The EIS Guidelines state that the EIS will present information in sufficient detail to enable the identification of how the project could affect the Valued Components and the analysis of those effects. In geological settings such as that of the Project, overburden can be the main unit through which seepage from mine facilities is transported, and is the unit through which groundwater is connected to surface water. The thickness and composition of the overburden is critical in understanding groundwater flow quantities, direction, and timing. No overburden has been described beyond 3m depth. If a higher hydraulic conductivity contact aquifer were present at the bedrock overburden interface this would not be apparent from logging. Additionally, it is stated that sands and gravels are present in the Victoria River Valley (Section 2.3 of BSA 3D). The presence of these materials would increase connectivity between the river and groundwater, and provide a more direct pathway for seepage from the tailings management facility to the river. Section 3.3 of Appendix 6A states the maximum thickness of the overburden varies from 10m (Section 3.3 of Appendix 6A) to over 17m (Section 2.2.1 of Appendix 6A). It is not clear which statement was applied within the numerical model, nor is it clear which assumptions were made in modelling the overburden thickness throughout the site. Representation of the overburden thickness and composition affects the assessment of changes to groundwater quantity and groundwater – surface water interaction. These changes should be integrated into the assessment of changes to surface water and fish habitat.
Information Request:	a. Provide a map of the simulated overburden thickness, including control points used. b. Provide information on the simulated maximum and minimum overburden thickness, and any assumptions used in the generation of the overburden thickness map. c. Provide information on the potential for increased hydraulic conductivity at the base of the till unit, and its impact on groundwater flow.

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	d. Provide a map of the presumed extent of sand and gravel within the Victoria River valley. Provide information on the impacts of this unit on groundwater – surface water interactions, and if necessary update the groundwater model to reflect the presence of this unit. Parameterization as needed.
Response:	a. A map of the simulated overburden thickness is provided in Figure IR-10.1. b. As presented in Section 2.2.1 of Appendix 6A of the EIS, the measured overburden thickness varied from 0.1 to 17.1 m. The simulated thicknesses presented on Figure IR-10.1 range from 0.1 to 20 m. The overburden thickness was calculated by creating a bedrock elevation surface from the data locations shown on Figure IR-10.1, and calculating the difference between the ground surface and the bedrock surface. As discussed in Table 4-1 of Appendix 6A of the EIS, the overburden was assigned a minimum thickness of 0.1 m within the model domain. c. No evidence of increased hydraulic conductivity at the base of the till unit was observed based on the results of hydraulic testing from eight monitoring wells completed in overburden and shallow bedrock at the site. d. The presumed extent of the sand and gravel within the Victoria River is defined by the extent of glaciofluvial deposits presented in the regional surficial geology maps presented in Figure 2-1 of the Appendix 6A of the EIS (attached). The hydraulic conductivity assigned to the overburden in the model is at the high end of the range for a sandy loam till, and falls within the range expected for glaciofluvial materials. Therefore, explicit simulation of the glaciofluvial deposits in the model is not required, and would not alter the groundwater flow patterns at the site.
Appendix:	None

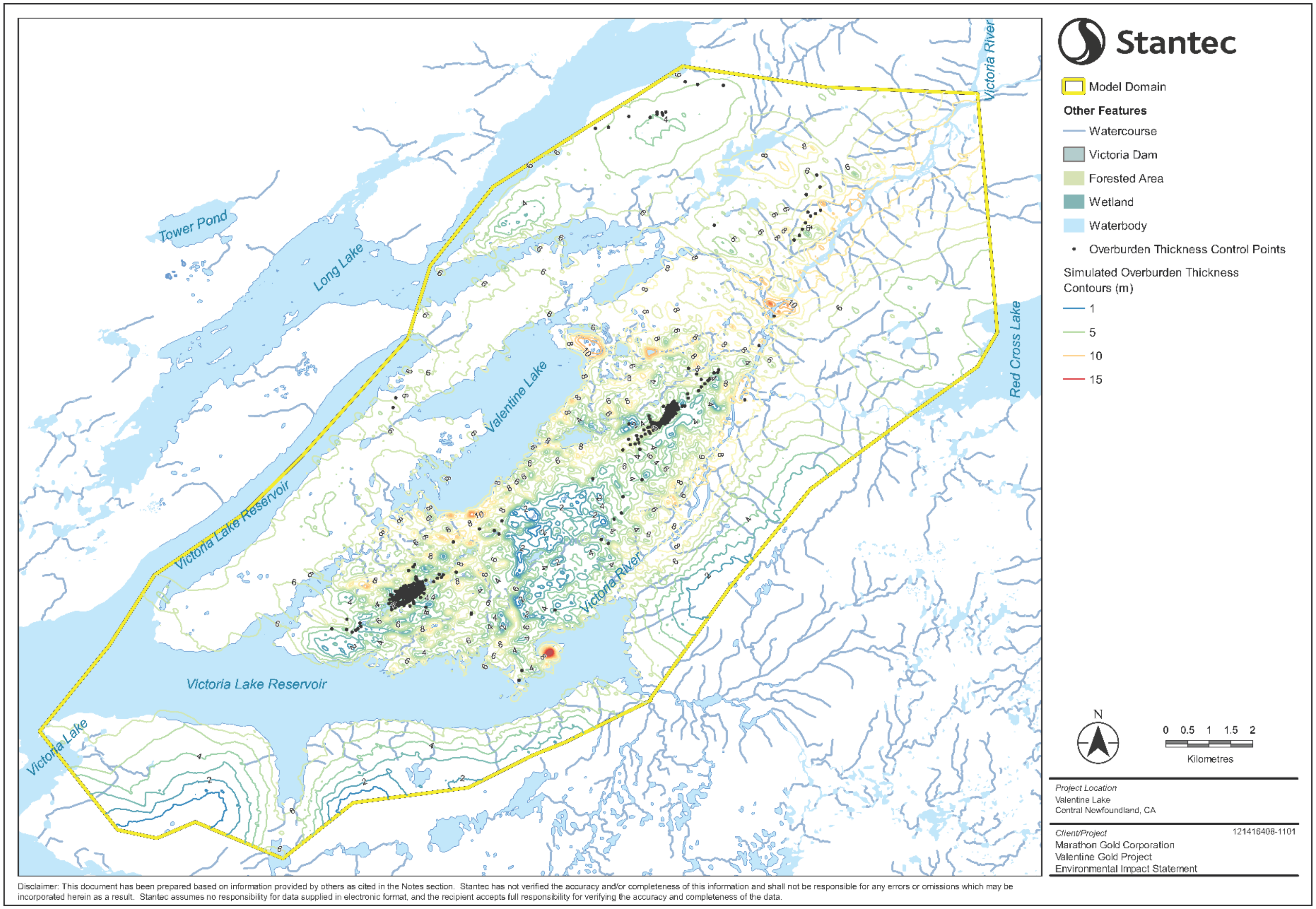

Figure IR-10.1 **Simulated Overburden Thickness**

RESPONSE TO IR-11

ID:	**IR-11**
Expert Department or Group:	NRCan-05
Guideline Reference:	7.1.5 Project Setting and Baseline Conditions – Groundwater and Surface Water7.2.2 Changes to Groundwater and Surface Water
EIS Reference:	Chapter 6, Appendix6A, Sections 4.3.3,4.3.4, Tables 5-1, 5-2, and 5-3, and Figures 4.1, 5.2 and 5.4
Context and Rationale:	The EIS Guidelines require the delineation and characterization of groundwater - surface water interactions. Boundary conditions within the groundwater flow model are user specified, and control the degree to which groundwater may interact with surface water. In the EIS, the Victoria River has been assigned a general head boundary condition. While this condition is reasonable for lakes with large catchment areas (such as Valentine Lake and the Victoria Lake Reservoir), groundwater drawdown in the vicinity of smaller lakes (such as the Middle, East and West Ponds, and Frozen Ear Lake), or in the upper reaches of the Victoria River, may result in lowering of the surface water levels. As shown on both Figures 5.2 and 5.4 of Appendix 6A, the assignment of these boundary conditions limits drawdown near these features during both operations and closure. The potential for these waterbodies to sustain the simulated flux to groundwater should be evaluated. In Section 4.5.4 it is noted that 2nd order or greater streams have been assigned a river boundary condition. Unlike a general head boundary, groundwater drawdown may occur below these features. However, the assumption that there is sufficient surface water flow to sustain continued flux to the groundwater remains. This assumption should be validated using water balances for these streams. In both cases, it is critical that these boundary conditions be applied only in cases where sufficient surface water flow is available to counter the loss of surface water to groundwater. Dewatering of surface water features and loss of fish habitat is possible with pit dewatering, and should be properly represented within the groundwater model. Although distant from the mine infrastructure, the northwest (abutting the northern reaches of Long Lake) and northeast (abutting Red Cross Lake) model boundaries appear to be set as no flow boundaries. These boundaries should be specified to reflect the lake elevation to ensure regional groundwater flow is represented.
Information Request:	a. Update the following information: Figure 4.1 of Appendix 6A so that the type, elevation, and location of all boundary conditions (General Head, River, and Drain) are clearly visible, including those at the boundary of the model. Tables 5-1 and 5-2 of Appendix 6A to include the boundary

ID:	**IR-11**
	condition type for each surface water feature listed. Include the Victoria River reach that is within the groundwater model. b. Complete a water balance for all surface water features for which a general head or river boundary has been applied. The water balances must be completed for baseline, operations and closure conditions. Compare the simulated flux to groundwater to available water, and update model boundaries accordingly.
Response:	a. Figure 4.1 has been updated to refine the presentation of boundary conditions and is presented as Figure IR-11.1. Tables 5-1 and 5-2 are updated with flux boundary types and presented as Tables IR-11.1 and IR-11.2, respectively. In the tables, GHB represents a "general head boundary" condition, and RIV represents a "river" boundary condition. As shown in the tables, waterbodies (i.e., lakes and ponds) were represented using GHBs, and more linear watercourses were represented with RIVs. GHBs and RIVs operate in a similar fashion, in that they allow inflows to or outflows from groundwater, at a rate based on the conductance assigned to the boundary condition, based on the stage of the surrounding aquifer. The main difference between how GHBs and RIVs operate is that RIVs have a maximum rate at which they can add water, defined by the bottom elevation assigned to the river (i.e., RBOT). This is illustrated on Figure IR-11.2. As discussed in Section 5.2.1 of Appendix 6A of the EIS, the general head boundaries and rivers in the vicinity of the pits were switched to drains as they are unlikely to maintain their constant heads or stages given the drop in water table associated with the pit drainage. b. The fluxes for the GHB, RIV, and drain (DRN) boundary conditions were extracted from the model using the General Head Boundary Observation Package, River Boundary Observation Package, or Drain Boundary Observation Package. These observation packages present the net fluxes only. In all cases, the net groundwater flow is to the streams and lake boundaries. Table IR-11.3 presents Table 5-3 from Appendix 6A of the EIS with the estimated baseline fluxes for the features based on the catchment areas at end of operation. Similarly, Table IR-11.4 presents Table 5-6 from Appendix 6A of the EIS with the estimated baseline fluxes for the features based on the catchment areas following post-closure. As shown on the tables, the net flows to the features are from groundwater to surface water. However, the mean annual flow rates in the streams are sufficient to maintain these net flows, should it be required.
Appendix:	None

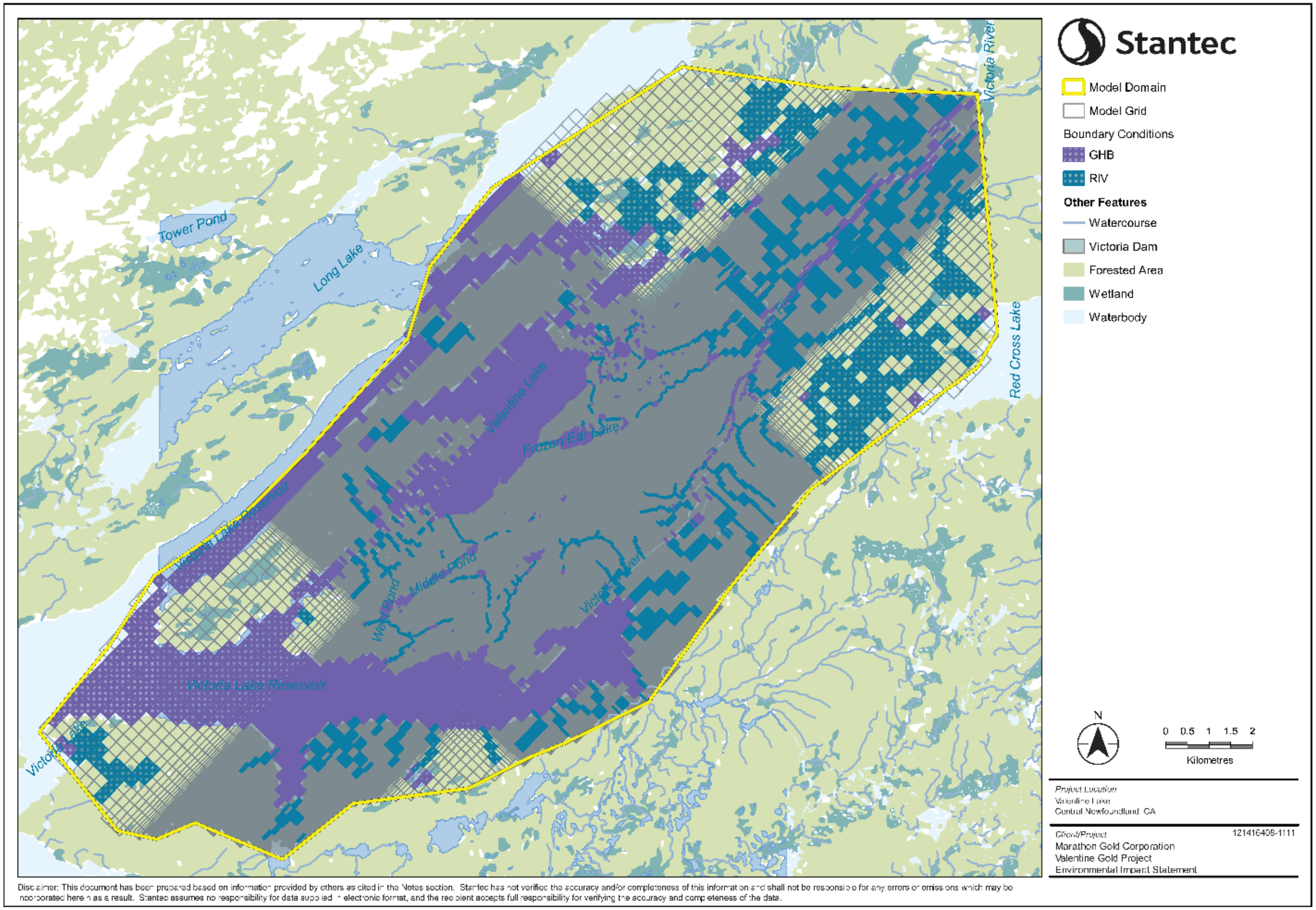

Figure IR-11.1 Model Domain and Boundary Conditions

Table IR-11.1 Baseline Groundwater Baseflow to Surface Water Features (formerly Appendix 6A, Table 5-1)

Water Feature	Net Flow from Groundwater to Feature (m^3/d)	Baseline Boundary Types
Unnamed Tributary to Victoria Lake Reservoir NT1	332.6	GHB - waterbodies RIV – watercourses
Unnamed Tributary to Victoria Lake Reservoir NT2	61.2	GHB – waterbodies RIV – watercourses
Frozen Ear Lake and Tributaries NT3	2874.2	GHB – waterbodies RIV – watercourses
Unnamed Tributary to Valentine Lake NT4	357.4	GHB – waterbodies RIV – watercourses
Unnamed Tributary to Valentine Lake NT5	408.4	GHB – waterbodies RIV – watercourses
Middle and East Pond and Tributaries EP1	919.9	GHB – ponds RIV – watercourses
West Pond and Tributaries WP1	2167.9	GHB – ponds RIV – watercourses
Unnamed Tributary to Victoria Lake Reservoir ST1	782.5	GHB – waterbodies RIV – watercourses
Unnamed Tributary to Victoria Lake Reservoir ST2	2872.6	GHB – waterbodies RIV – watercourses
Unnamed Tributary to Victoria River ST3	1306.4	RIV – watercourses
Unnamed Tributary to Victoria River ST4	5201.6	GHB – waterbodies RIV – watercourses
Unnamed Tributary to Victoria River VR1	0.002	RIV – watercourses
Unnamed Tributary to Victoria River VR2	0.2	RIV – watercourses
Unnamed Tributary to Victoria River VR3	153.5	GHB – waterbodies RIV – watercourses
Unnamed Tributary to Victoria River VR4	12	RIV – watercourses

Table IR-11.2 Estimated Groundwater Discharge to Surface Water Features under Operation Phase (formerly Appendix 6A, Table 5-3) With Boundary Condition Types

Water Feature	Net Flow from Groundwater to Feature (m^3/d)		Operation Boundary Types
	Baseline	Operation	
Unnamed Tributary to Victoria Lake Reservoir NT1	332.6	623.7	DRN – watercourses
Unnamed Tributary to Victoria Lake Reservoir NT2	61.2	768.6	DRN – watercourses
Frozen Ear Lake and Tributaries NT3	2874.2	2349.8	RIV – watercourses
Unnamed Tributary to Valentine Lake NT4	357.4	13	RIV – watercourses
Unnamed Tributary to Valentine Lake NT5	408.4	367.6	DRN – watercourses GHB – waterbodies
Middle and East Pond and Tributaries EP1	919.9	547.4	RIV – watercourses GHB – waterbodies
West Pond and Tributaries WP1	2167.9	751.6	RIV – watercourses
Unnamed Tributary to Victoria Lake Reservoir ST1	782.5	614.9	DRN – watercourses GHB – waterbodies
Unnamed Tributary to Victoria Lake Reservoir ST2	2872.6	2469.3	RIV – watercourses GHB – waterbodies
Unnamed Tributary to Victoria River ST3	1306.4	208.1	DRN – watercourses
Unnamed Tributary to Victoria River ST4	5201.6	3113.4	RIV – watercourses
Unnamed Tributary to Victoria River VR1	0.002	206.4	DRN – watercourses
Unnamed Tributary to Victoria River VR2	0.2	387	DRN – watercourses
Unnamed Tributary to Victoria River VR3	153.5	962.3	DRN – watercourses GHB – waterbodies
Unnamed Tributary to Victoria River VR4	12	1947.4	DRN – watercourses

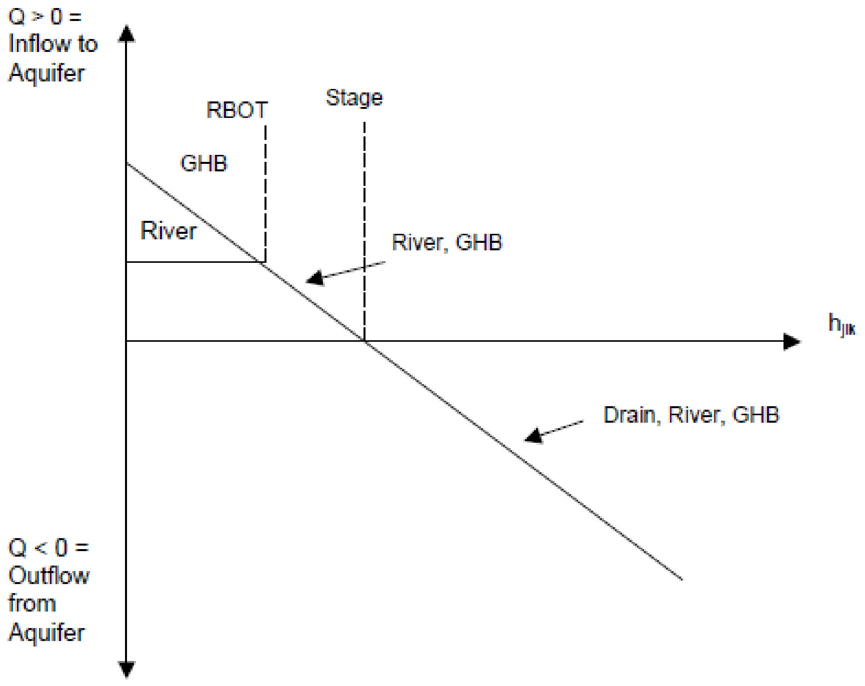

Figure IR-11.2 **Model Domain and Boundary Conditions**

Table IR-11.3 Estimated Groundwater Discharge to Surface Water Features under Operation Phase (formerly Appendix 6A, Table 5-3) with Mean Annual Flowrates

Water Feature	Net Flow from Groundwater to Feature (m^3/d)		Mean Annual Flow (m^3/d)
	Baseline	Operation	
Unnamed Tributary to Victoria Lake Reservoir NT1	332.6	623.7	1580.7
Unnamed Tributary to Victoria Lake Reservoir NT2	61.2	768.6	2157.1
Frozen Ear Lake and Tributaries NT3	2874.2	2349.8	8739.5
Unnamed Tributary to Valentine Lake NT4	357.4	13	1077.9
Unnamed Tributary to Valentine Lake NT5	408.4	367.6	1552.9
Middle and East Pond and Tributaries EP1	919.9	547.4	6710.2
West Pond and Tributaries WP1	2167.9	751.6	6633
Unnamed Tributary to Victoria Lake Reservoir ST1	782.5	614.9	3481
Unnamed Tributary to Victoria Lake Reservoir ST2	2872.6	2469.3	5787.1
Unnamed Tributary to Victoria River ST3	1306.4	208.1	3934.4
Unnamed Tributary to Victoria River ST4	5201.6	3113.4	17021.8
Unnamed Tributary to Victoria River VR1	0.002	206.4	837.5
Unnamed Tributary to Victoria River VR2	0.2	387	968.5
Unnamed Tributary to Victoria River VR3	153.5	962.3	2219.5
Unnamed Tributary to Victoria River VR4	12	1947.4	1705.2

Table IR-11.4 Estimated Groundwater Discharge to Surface Water Features under Closure Phase (formerly Appendix 6A, Table 5-6) with Mean Annual Flowrates

Water Feature		Net Flow from Groundwater to Feature (m^3/d)		Mean Annual Flow (m^3/d)
	Baseline	End of Post-Closure (with ditches)	End of Post-Closure (without ditches)	
Unnamed Tributary to Victoria Lake Reservoir NT1	332.6	625.8	623.8	1580.7
Unnamed Tributary to Victoria Lake Reservoir NT2	61.2	769.5	769.5	2157.1
Frozen Ear Lake and Tributaries NT3	2874.2	2330.4	2481.1	8739.5
Unnamed Tributary to Valentine Lake NT4	357.4	173	327.1	1077.9
Unnamed Tributary to Valentine Lake NT5	408.4	367.7	548.6	1552.9
Middle and East Pond and Tributaries EP1	919.9	560.7	565.8	6710.2
West Pond and Tributaries WP1	2167.9	953.5	1197	6633
Unnamed Tributary to Victoria Lake Reservoir ST1	782.5	616.6	972.5	3481
Unnamed Tributary to Victoria Lake Reservoir ST2	2872.6	2468.7	2525.8	5787.1
Unnamed Tributary to Victoria River ST3	1306.4	139.5	852.6	3934.4
Unnamed Tributary to Victoria River ST4	5201.6	3355	3691.9	17021.8
Unnamed Tributary to Victoria River VR1	0.002	206.2	206.3	837.5
Unnamed Tributary to Victoria River VR2	0.2	348.7	361.4	968.5
Unnamed Tributary to Victoria River VR3	153.5	879.4	627.9	2219.5
Unnamed Tributary to Victoria River VR4	12	2043.1	2050.4	1705.2

RESPONSE TO IR-12

ID:	**IR-12**
Expert Department or Group:	NRCan-06
Guideline Reference:	Section 7.1.5
EIS Reference:	Appendix 6A, Section 4.4, Tables 4-2 and 4-3, and Figures 4-3 and 4-4
Context and Rationale:	The EIS Guidelines require the delineation and characterization of groundwater - surface water interactions. Without a reasonable calibration of the groundwater model, any forecasted changes to groundwater quantity, or groundwater-surface interaction are not reliable. These results are then transferred to the assessment of surface water flow, and subsequently fish and fish habitat. Although it was stated in the EIS that calibration to baseflow was conducted, no results have been provided. Simulated baseflow may be sensitive to parameters such as river conductance, recharge, and the hydraulic conductivity of the overburden. Given that the calibrated value of river conductance is a factor of 26 times greater than the host overburden (a much higher conductance factor than is typical), calibration to baseflow should be presented and justified. Calibration to water levels was conducted primarily using data from long open exploration holes (96% of data). An open hole can connect several hydrostratigraphic units (HSUs) such that groundwater elevations are representative of several units. As a result, differentiation of the water levels in the various HSUs is difficult. While several methods are available to integrate this type of data into a calibration process, the method chosen should be discussed, as should its implications on calibration. Calibration to water levels is evaluated by comparing simulated to observed groundwater elevation values at the various observation points (Shown on Figure 4-3 and summarized in Table 4-2). Results show that the modelled groundwater levels tend to be higher than observed at low elevations, and lower than observed at high elevations. These results indicate that the model may underrepresent the observed magnitude of hydraulic gradients. Magnitude of error should be discussed in both a spatial and geological sense, and its implications on model performance should be discussed. Although automated calibration can efficiently generate parameter sets that minimize errors, the solution is non-unique, meaning that other possible parameter combinations may yield the same result. As such, it is important that results are evaluated to ensure that they align with observations and the conceptual model. In Section 4.4.3 it is stated that the calibrated hydraulic conductivity is generally less than that observed in the single well tests. This result does not seem to be consistent with the accepted observation that hydraulic conductivity increases with scale (e.g., Schulze-Makuch et

ID:	**IR-12**
	al., 1999). Although it is noted that bedding in the bedrock units follows the near vertical dip of the units, the calibrated anisotropy value results in a higher hydraulic conductivity across the bedding planes. This result is inconsistent with typical conceptualization. As discussed in NRCan-04 these results may indicate that the modelled hydrostratigraphy is not aligned with observations. As shown on Figure 4-4, recharge is the most sensitive parameter in the calibration. The calibrated recharge value is validated against an assumed range for all of Newfoundland. However, sufficient water balance data is presented in Baseline Study Appendix 3C Section 4.1 that would allow calibrated recharge to be compared to a local annual water surplus. Given that hydraulic conductivity parameters are outside of the assumed range, calibrated recharge warrants this level of comparison. Reference: Schulze-Makuch, D., Carlson, D. A., Cherkauer, D. S. & Malik, P. Scale Dependency of Hydraulic Conductivity in Heterogeneous Media. Groundwater 37, 904–919 (1999).
Information Request:	a. Discuss the calibration of the groundwater model to baseflow. Provide a rationale for the river conductance factor derived from the calibration. b. Describe the methodology for specifying the exploration holes as observation wells in the groundwater model. If each hole is assigned to a single HSU, include this unit in Table 4-2, and colour the data by HSU on Figure 4-3. Discuss the number of observation points in each HSU. c. Discuss calibration to water levels in terms of HSU and spatial location. reevaluate the calibration to ensure hydraulic gradients are properly represented. d. Review and update the hydrostratigraphic conceptualization and its effect on calibrated hydraulic conductivity and anisotropy values. e. Provide details on the presentation of two overburden units on Figure 4-4, which are not included in Table 4-3. f. Discuss calibrated recharge relative to site water balance data.
Response:	a. The calibration of the groundwater flow model to baseflow was conducted for six surface water monitoring locations presented on Table IR-12.1. As shown on the table, a good match of the baseflow in the model to the targets was obtained, ranging from 0.3 to 28%, with an average match of 12%. The river conductance was fit during calibration. The conductance term controls the interaction of the boundary condition to the aquifer, and conceptually simulates a stream or lake bed material. The higher the conductance, the better the connection of the water level in the boundary with the water level in the aquifer cell the boundary condition

ID:	**IR-12**
	is located. The flow rates between the aquifer and the boundary conditions tend to vary linearly as the conductance rate increases from low to high but flattens to a peak value that is governed by the flow from the aquifer to the boundary. In this case, the conductance value suggests the boundary condition has a good connection with the aquifer, and the flow rate is governed by the aquifer properties rather than the lakebed or riverbed materials. b. The screen intervals for monitoring wells, or open intervals for the bedrock wells were assigned in the model. The water levels for these intervals were calculated in ModelMuse using the Modflow Head Observation (HOB) package (Hill et al. 2000). These multi-layer water level observations were calculated using the average of the transmissivity-weighted water levels in each layer intersected. c. The distribution of residual water levels (i.e., simulated - observed) by elevation is shown on Figure IR-12.1. As shown, there is a slight bias to overestimate the water levels in the lower elevations, and to slight bias to underestimate the water levels at higher elevations. However, the majority (i.e., 59%) of the water level residuals are within 2 m of the target, with 29% of the residuals between 2 and 5 m, and 12% of residuals greater than 5 m. d. Vertical anisotropy is challenging to measure in the field, and is often applied in groundwater practice with a rule of thumb assumption of vertical hydraulic conductivity an order of magnitude lower than the horizontal. However, this simplifying assumption can vary significantly due to actual hydrogeological conditions. As shown on Table 4-3 of Appendix 6A of the EIS, the vertical anisotropy was allowed to vary within the model between 0.05 and 5. The vertical anisotropy within the bedrock was fit at the low end of this range (0.05), suggesting that vertical flow into the deeper bedrock is limited. e. Figure 4-4 presented in Appendix 6A of the EIS referenced an earlier iteration of PEST that discretized the hydraulic conductivity of the overburden into two layers. The results of that PEST run arrived at a uniform hydraulic conductivity for the two layers, and because it was uniform, a single value for hydraulic conductivity for the till overburden was presented in Table 4-3 of Appendix 6A of the EIS. The overall sensitivities presented in Appendix 6A of the EIS are unchanged, with the recharge and overburden hydraulic conductivity remaining the most sensitive parameters.

ID:	**IR-12**
	f. The calibrated recharge rate of 381 mm/yr is able to match the overall head distribution within a normalized RMS of water levels of 2.7%, and an average baseflow in stream measurements of 12%. Reference: Hill, M.C., E.R. Banta, A.W. Harbaugh, and E.R. Anderman. 2000. MODFLOW-2000, the U.S. Geological Survey modular ground-water model -- User guide to the Observation, Sensitivity, and Parameter-Estimation Processes and three post-processing programs: U.S. Geological Survey Open-File Report 00-184, 210 p.Attachment: https://marathongold.stanport.com/Shared%20Documents/IR-12.docx
Appendix:	None

Table IR-12.1 Baseflow Calibration in Groundwater Flow Model

Surface Water Station	Observed	Simulated	% Difference
HS3_1	700	587	-16%
HS5_1	997	782	-22%
HS1_1	401	515	28%
HS7_1	1737	1805	3.9%
HS9_1	2918	2894	-0.8%
HS8_1	5058	5040	0.3%

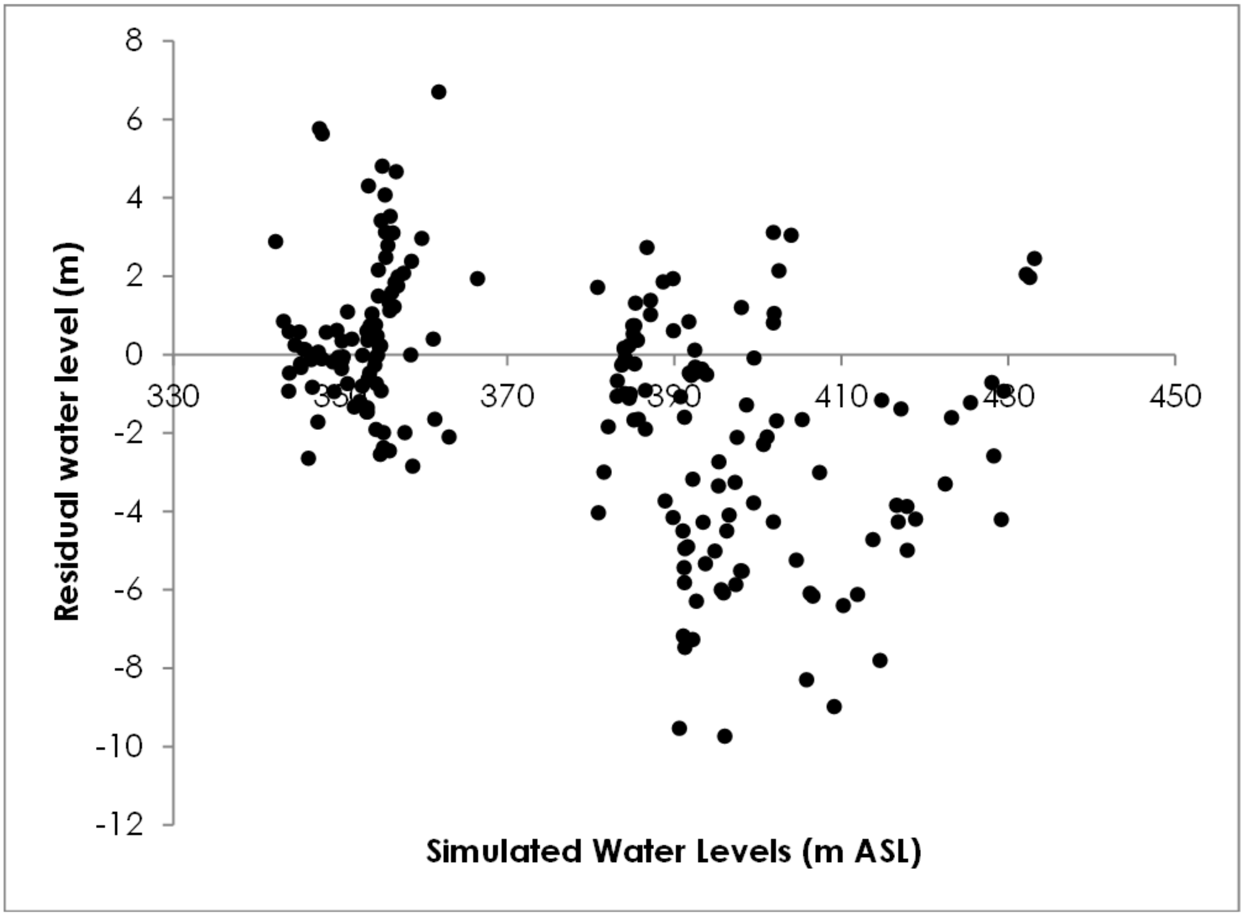

Figure IR-12.1 Distribution of model residuals (simulated – observed water levels) by observed water level elevation

RESPONSE TO IR-13

ID:	**IR-13**
Expert Department or Group:	NRCan-07
Guideline Reference:	Section 7.1.5
EIS Reference:	Appendix 6A, Section 5.2.1.2
Context and Rationale:	The EIS Guidelines require information on groundwater flow patterns and rates. The effect of the Valentine Lake Thrust Fault on groundwater flow was assessed through a sensitivity analysis. The results of this analysis were evaluated in terms of groundwater inflow to the open pit under operational conditions. While this mode of analysis is required for water management purposes, it neglects to account for related changes in groundwater elevations. An increased hydraulic conductivity in the fault zone more than doubles the groundwater inflow to the open pits. As stated in Section 5.2.1.2 of Appendix 6A, the simulated fault plane connects the pits to Victoria Lake. Given this connection, simulations which include the fault are likely to result in changes to groundwater-surface water flux rates for Victoria Lake and the small lakes proximal to the pits. Expanded evaluation of the fault scenarios is required.
Information Request:	a. Provide groundwater elevation maps for baseline conditions for both fault scenarios. Discuss the effect of the fault scenarios on model calibration and groundwater flow in both overburden and bedrock under baseline conditions. b. Provide groundwater elevation and drawdown maps for both fault scenarios in both operations and closure. Groundwater drawdown information should be provided for both the water table and within the bedrock at the depth of maximum drawdown. c. Provide tables summarizing the changes in baseflow to surface water bodies for both fault scenarios under both operations and closure. d. Complete particle tracking for both fault scenarios under both operations (from the Low Grade Ore Stockpile and Waste Rock Pile) and closure (from the Low Grade Ore Stockpile, Waste Rock Pile, and backfilled tailings).
Response:	Recent packer testing data provided in the response to IR-09 indicate that the hydraulic conductivities determined for the Marathon and Leprechaun deposit faults (including the Valentine Lake thrust fault) were within the range of values for the various rock types, and were not found to be hydraulically distinct from the surrounding rock mass. This continues to support the assumption that the faults in the proposed open pits are not

ID:	**IR-13**
	expected to be substantial preferred pathways for groundwater flow, or constitute problem areas for seepage control. Therefore, the baseline values remain valid for the assessment of potential effects. a. Groundwater elevation maps for the baseline conditions are presented for the 10 times higher K fault scenario in Figure IR-13.1, and for the 10 times lower K fault scenario in Figure IR-13.2 (Appendix IR-13.A). The fault scenarios do not significantly alter the groundwater flow rates or calibration results in either case. b. Groundwater elevation and drawdown maps for the water table, which includes the drawdowns associated within the bedrock in the open pits, are presented as outlined below. Groundwater elevation and drawdown maps for the operation conditions for the 10 times higher K fault scenarios are presented in Figures IR-13.3 and IR-13.4 (Appendix IR-13.A), respectively. Groundwater elevation and drawdown maps for the operation conditions for the 10 times lower K fault scenarios are presented in Figures IR-13.5 and IR-13.6 (Appendix IR-13.A), respectively. Groundwater elevation and drawdown maps for the post-closure conditions for the 10 times higher K fault scenarios are presented in Figures IR-13.7 and IR-13.8 (Appendix IR-13.A), respectively. Groundwater elevation and drawdown maps for the post-closure conditions for the 10 times lower K fault scenarios are presented in Figures IR-13.9 and IR-13.10 (Appendix IR-13.A), respectively. c. Tables summarizing the baseflow to surface water bodies for both fault scenarios are presented in Table IR-13.1 for operations and Table IR-13.2 for post-closure (Appendix IR-13.A). d. Particle tracking results for the fault scenarios are presented for operations in Figures IR-13.11 and IR-13.12 and for post-closure in Figures IR-13.13 and IR-13.14 (Appendix IR-13.A). Note that the low-grade ore stockpile will not be present during post-closure as it will be processed at the end of operations. Therefore, post-closure figures do not include particle tracks from the low-grade ore stockpiles.
Appendix:	Appendix IR-13.A

RESPONSE TO IR-14

ID:	**IR-14**
Expert Department or Group:	NRCan-08
Guideline Reference:	Section 7.1.5
EIS Reference:	Appendix 6A, Sections5.2.2 and 5.3.2, Tables 5-3 and 5-6. And Figures 5-2 and 5-4
Context and Rationale:	The EIS Guidelines require the delineation and characterization of groundwater - surface water interactions. Baseflow, or groundwater discharge to surface water, can be the main sustaining flow for surface water bodies during periods of low precipitation. This flow can be critical to fish, fish habitat and other aquatic species. Changes to baseflow, or changes to the flux between groundwater and a surface water body is one of the key outputs from the groundwater model, and feeds the assessment of effects to other Valued Components. To assess model results, groundwater drawdown can be compared to simulated changes in groundwater discharge to surface water. Maps on Figures 5-2 and 5-4 of Appendix 6A of the EIS show simulated groundwater drawdown under operations and closure conditions. However, it does not appear that all of the waterbodies listed in Tables 5-3 and 5-6 of Appendix 6A of the EIS are shown on the map (e.g., VR4). It is also apparent that not all of the water bodies in the model have been included in Tables 5-3 and 5-6 of Appendix 6A of the EIS. Specifically, the reach of the Victoria River that falls within the model domain is not reported. Results in Table 5-3 and 5-6 of Appendix 6A of the EIS both indicate that waterbodies NT1 and NT2 receive more groundwater discharge in operations and closure relative to baseline conditions. This table appears to be inconsistent with the drawdown shown on Figures 5-2 and 5-4 of Appendix 6A of the EIS, as well as the discussion within the text. Additionally, waterbody ST3 appears to lose between 500 and 1000 m3/day of groundwater discharge in operations and closure. This water body is outside of the zone of influence of the pits, and within an area of increased groundwater elevations due to the presence of the tailings management facility. These results should be evaluated against expected outcomes.
Information Request:	a. Update maps provided in Table 5-3 and 5-6 of Appendix 6A of the EIS to ensure that all waterbodies are clearly labelled. b. Where the results shown in Table 5-3 and 5-6 of Appendix 6A of the EIS appear to be inconsistent with the water table drawdown or expected results, correct values that are reported, and discuss any rationale for the discrepancy.

ID:	**IR-14**
	Provide simulated changes to groundwater-surface water exchange rates for the reach of the Victoria River that is within the model domain under both operations and closure conditions. Discuss these results in comparison to a water balance for this reach of the river, and ensure sufficient surface flow is available to maintain any flux to groundwater.
Response:	a. The waterbodies presented on Table 5-3 and 5-6 of Appendix 6A of the EIS are presented with labels on Figures 4-2a, 4-2b, 4-2c, and 5-1 to 5-5 of Appendix 6A of the EIS. The waterbodies are presented with labels on Figure IR-14.1. b. The results presented in Tables 5-3 and 5-6 of Appendix 6A of the EIS are consistent with the results from the groundwater modelling. The following responses are provided to explain the context of the perceived discrepancies. Although the groundwater modelling indicates that the water table is lowered during operations and post-closure compared to baseline conditions, the net groundwater flow to waterbodies NT1 and NT2 are predicted to increase for both these scenarios. This appears to be related to changing the boundary condition types for NT1 and NT2 from RIV to DRN (see IR-11). The net flows at NT1 and NT2 under baseline conditions appears to have had some of the cells simulating flow in the opposite direction (i.e., from surface water to groundwater) rather than from groundwater to surface water during operations. However, this does not affect the interpretations of effects on these features. Waterbody ST3 appears to lose between 500 and 1000 m^3/d of groundwater discharge in operations and closure due to the operation of the seepage collection ditch at the base of the Tailings Management Facility, which intercepts groundwater flow to this feature during baseline conditions. c. The groundwater-surface water exchange rates for the reach of the Victoria River within the model domain is 19,748.8 m^3/d for operation, and 19,882.9 m^3/d for post-closure conditions. Victoria River is a natural groundwater discharge zone, and these rates represent net contributions to surface water from groundwater. Therefore, no surface flow is required to maintain the fluxes to groundwater.
Appendix:	None

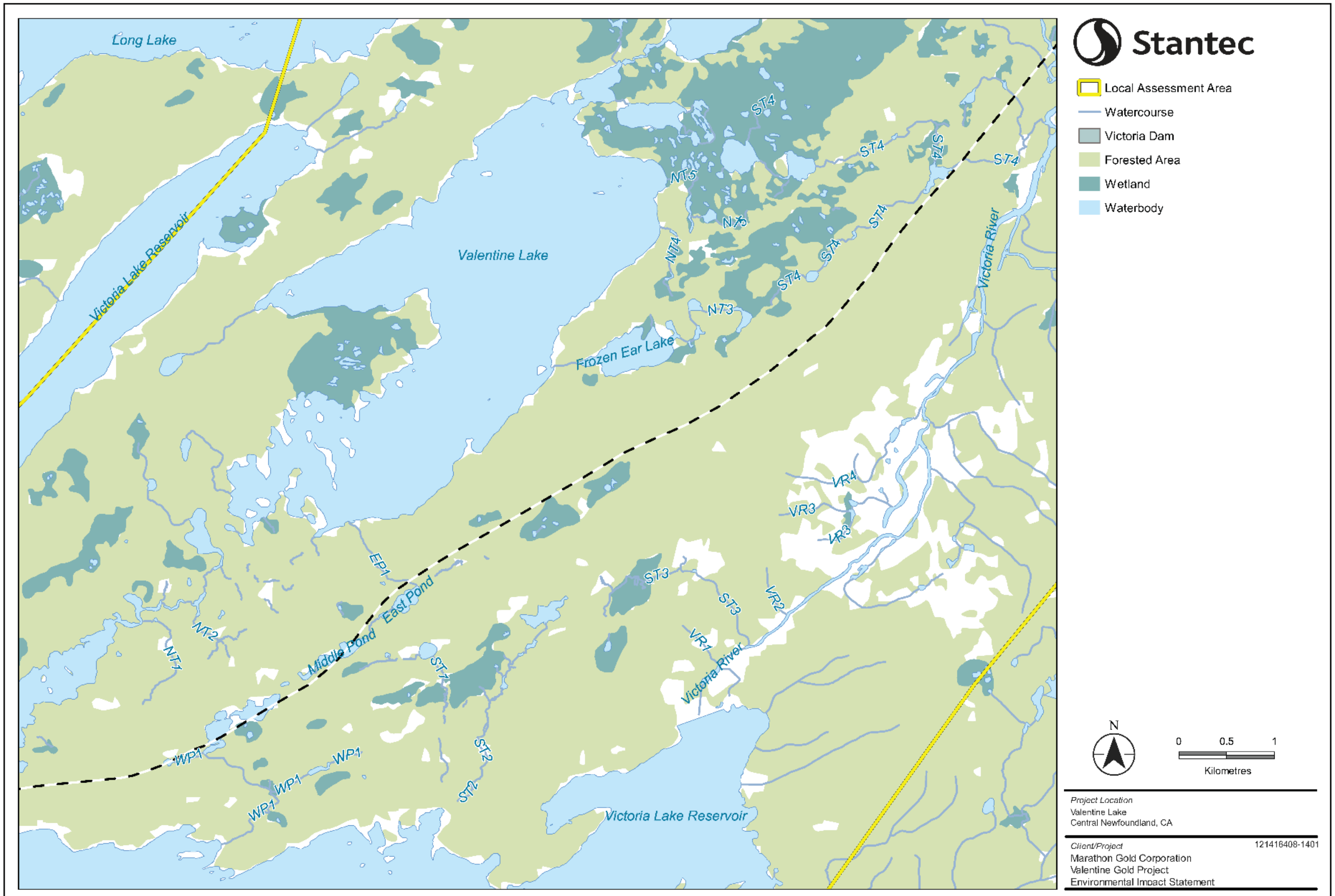

Figure IR-14.1 **Water Features Included in the Groundwater Modelling**

RESPONSE TO IR-15

ID:	**IR-15**
Expert Department or Group:	NRCan-09
Guideline Reference:	Section 7.2.2
EIS Reference:	Appendix 6A, Sections5.2.1.3 and 5.3.1.2, Tables 5-4, 5-6, and 5- 7.
Context and Rationale:	The EIS guidelines require information on surface and seepage water quality from the waste rock dumps, tailings/waste rock impoundment facility, stockpiles and other infrastructure during operation and post-closure. The quantity of groundwater seepage that originates from waste rock storage facilities and discharges to surface water bodies is used to assess water quality within these waterbodies. Implementation of these facilities and their seepage collection infrastructure within the groundwater model has implications on these assessment results. As reported in Section 5.2.1.3 of the EIS, during operations, recharge was applied to the waste rock pile at a rate of 82% of precipitation (indicating that the remaining 18% does not infiltrate the pile and runs off). However, results in Table 5-4 are presented as percentage of total infiltration, and sum to 82%. These results appear to suggest that 18% of the applied recharge is not accounted for within the table. During closure, as reported in Section 5.3.1.2 of the EIS, recharge rates for the facilities were changed to a post-closure value, which is meant to reflect changes in grading and vegetation. This value is not provided. In review of the results in Table 5-7, again presented as a percentage of total infiltration, the total for the Leprechaun facility appears to be 50%, while the total for the Marathon facility appears to be 82%. These discrepancies should be clarified such that all applied recharge to the facilities is accounted for, and that the value of recharge applied is clear within the report. Results presented in Tables 5-4 and 5-7 of the EIS indicated that the majority of the seepage from the waste rock facilities is captured by the ditch network and seepage collection ponds. These features limit the amount of seepage received by the natural environment. As stated in section 5.2.1.3 of the EIS ditches were specified as 25m wide, aligned with the model grid size. Based on results shown in Table 5-6, these ditches appear to capture a large quantity of groundwater. The setting of 25m wide ditches may over-represent the zone of influence of the seepage collection system, and model results may underestimate the quantity of groundwater seepage that bypasses these systems. The timing of the arrival of seepage at the various groundwater discharge points has implications for the ability to monitor and mitigate the effects of this seepage. Results from the model should include travel time from the facilities to the discharge points.

ID:	**IR-15**
Information Request:	a. Provide the recharge value applied to the waste rock facilities in both operations and closure, and the method used to derive this value. Present the results in a table (like Tables 5-4 and 5-7 of the EIS), either as percent of recharge or flux value. Discuss any discrepancies between recharge applied and total seepage that was accounted for. b. Include the results for the closure scenario without ditches in the assessment of the seepage of the waste rock facility. c. Include an assessment of the travel time for seepage from the facilities to the discharge points. Include a discussion of the parameterization of this assessment.
Response:	a. The recharge rate applied to the waste rock piles (WRPs) in the groundwater flow model for both operation and closure scenarios is 243 mm/yr, and is derived as presented in Appendix 7A. The operation and closure values remain unchanged as the sloping and regrading of the waste rock materials is assumed to have negligible effects on the infiltration to the WRPs. The results presented in Table 5-4 of the EIS are presented relative to total precipitation on the WRPs, and not total infiltration. b. The assessment of seepage from the WRPs without ditches was not conducted for the post-closure period because the seepage water quality from the WRPs collected in the seepage collection ditches would naturally seep from the toe of the WRPs and would travel overland. It is assumed that some natural channel would remain post-closure to direct the seepage from the WRPs to watercourses. Therefore, drainage ditches, rather than seepage collection ditches, will remain at the WRPs post-closure. c. The travel time for seepage from the facilities to the discharge points are shown on Table IR-15.1 for operations, and Table IR-15.2 for post-closure conditions. This is based on the porosity of the geological units presented in Table IR-16.1.
Appendix:	None

Table IR-15.1 Groundwater Travel Times (Years) from Waste Rock Piles and LGO Stockpiles - Operation Phase

Receptor	Waste Rock Pile (min | mean | max)	Low-Grade Ore Stockpile (min | mean | max)
Leprechaun Complex		
Leprechaun Pit	49646 | 608634 | 1627083	-
LP-SP-01A	-	<1 | 19 | 98
LP-SP-01B	<1 | 9 | 47	75 | 120 | 227
LP-SP-02A	<1 | 39 | 333	201 | 239 | 321
LP-SP-02B	1 | 52 | 509	-
LP-SP-03A	<1 | 21 | 162	-
LP-SP-03B	<1 | 37 | 350	-
Victoria Lake Reservoir	1 | 63721 | 1950393	-
Marathon Complex		
Marathon Pit	1 | 3705636 | 19086552	2713 | 1458938 | 6075249
MA-SP-01A	-	10 | 55 | 191
MA-SP-01B	-	27 | 120 | 319
MA-SP-01C	<1 | 11 | 133	-
MA-SP-02	<1 | 125 | 81018	-
MA-SP-03	<1 | 157 | 55775	-
MA-SP-04	<1 | 15 | 249	-
Frozen Ear Lake and Tributaries NT3	2 | 184 | 435	11 | 200 | 2322
Unnamed Tributary to Valentine Lake NT5	1 | 282 | 35537	-
Unnamed Tributary to Victoria River ST4	7 | 5049 | 118300	-
Unnamed Tributary to Victoria River VR4	-	106 | 296 | 7019

Table IR-15.2 Groundwater Travel Times (Waste Rock Piles and LGO Stockpiles) – Post-Closure Phase

Receptor	Waste Rock Pile (min | mean | max)
Leprechaun Complex	
Leprechaun Pit	193988062 | 195735923 | 197483784
LP-SP-01A	-
LP-SP-01B	<1 | <1 | 1
LP-SP-02A	<1 | 39 | 400
LP-SP-03A	<1 | 22 | 198
LP-SP-03B	<1 | 25 | 134
Marathon Complex	
Marathon Pit	1 | 561661302 | 49962837189
MA-SP-01A	-
MA-SP-01B	-
MA-SP-01C	<1 | 19 | 133
MA-SP-02	<1 | 29 | 10215
MA-SP-03	<1 | 26 | 2357
MA-SP-04	<1 | 331 | 108708
Frozen Ear Lake and Tributaries NT3	<1 | 7816958 | 8795320387
Unnamed Tributary to Valentine Lake NT5	<1 | 123 | 26145
Unnamed Tributary to Victoria River ST4	1 | 6884312 | 518355893

RESPONSE TO IR-16

ID:	**IR-16**
Expert Department or Group:	NRCan-10
Guideline Reference:	Section 7.2.2
EIS Reference:	Appendix 6A, Sections5.2.1.4 and 5.3.1.2
Context and Rationale:	The EIS guidelines require information on surface and seepage water quality from the waste rock dumps, tailings/waste rock impoundment facility, stockpiles and other infrastructure during operation and post-closure. Similar to seepage from waste rock facilities, the quantity of groundwater seepage that originates from the Tailings Management Facility (TMF) and discharges to surface waterbodies is important to the assessment of water quality, as it affects the assessment of fish and fish habitat. As discussed in Appendix 6A of the EIS, a contaminant transport approach using MT3D was implemented to generate an attenuation factor for seepage from the TMF prior to discharge to the Victoria River. To review the assessment of TMF seepage, the details of the parameterization of the MT3D model should be provided. Results of the model including the quantity of seepage, point of discharge (i.e., Victoria River or its tributaries) and travel time should be provided.
Information Request:	Provide details of the MT3D model set-up, including parameterization. Discuss the results of the MT3D model in terms of seepage quantity, seepage discharge points, and travel time.
Response:	The simulation considers the transport of a conservative solute from the seepage water from the Tailings Management Facility (TMF) with a source concentration of 1 mg/L through groundwater to the receiving environment over time. The solute is considered to be conservative because it is assumed to have the diffusion coefficient of chloride, a conservative tracer. Solute transport was conducted for a period of 500 years. The solute transport model was set up using the transport parameters shown on Table IR-16.1. Porosity for each geologic material is based on the mid-range of expected values from the literature. Dispersivity is assumed based on the spatial scale of solute transport. Source terms for the seepage water quality from the TMF were assumed to be the same as the tailings pore water quality, as presented in Appendix 7A of the EIS. The source terms are multiplied by the relative concentrations generated by the model to estimate the mass loading and average concentrations of groundwater discharging to surface water receptors. Groundwater seepage from the base of the TMF that is not collected in the TMF seepage collection ditches is projected to discharge to Victoria River,

ID:	**IR-16**
	and tributary VR-3. The rate of discharge to the watercourse at the maximum extent of the groundwater plume, and associated travel time statistics (minimum, mean, and maximum) are presented on Table IR-16.2. As discussed in Section 5.3.2 of Appendix 6A of the EIS, the attenuation ratio of seepage from the base of the TMF discharging to Victoria River was calculated following 100 years of post-closure conditions. This attenuation ratio is conservative in nature, as it assumes a constant, non-depleting source concentration at the TMF, with no chemical reactions in the groundwater flow system. As shown on Table IR-16-2, some additional mass will continue to be added to the plume, however, the rate that the concentrations at these locations will increase is predicted to stabilize, and will not change the attenuation ratio substantively, based on the conservative nature of the calculation of the attenuation ratio.
Appendix:	None

Table IR-16.1 Assigned and calibrated solute transport model parameter values

Parameter	Assigned Value
Porosity	
Overburden Units	0.25
Weathered Bedrock	0.1
Competent Bedrock	0.05
Tailings	0.25
Dispersivity (All Geological Units)	
Longitudinal (m)	10
Transverse and Vertical (m)	1
Solute Species	
Diffusion Coefficient (m^2/s)	1.4×10^{-9}

Table IR-16.2 Seepage Rates and Travel Times from TMF to Surface Water Receivers

Receiver	Groundwater Seepage Rate (m^3/d)	Travel Times (Years)		
		Minimum	Mean	Maximum
Victoria River	5355	45	171	415
Unnamed Tributary to Victoria River (VR3)	467	7	104	251

RESPONSE TO IR-17

ID:	**IR-17**
Expert Department or Group:	NRCan-11
Guideline Reference:	Section 7.2.2
EIS Reference:	EIS Chapter 2, Section 2.6.3.3, Appendix 6A, Figure 5-4
Context and Rationale:	The EIS guidelines require information on surface and seepage water quality from the waste rock dumps, tailings/waste rock impoundment facility, stockpiles and other infrastructure during operation and post-closure. The EIS states that following the exhaustion of the Leprechaun Pit in year 9, tailings will be backfilled within the pit. These tailings represent a potential source of mining impacted groundwater seepage, which may affect fish and fish habitat should hydraulic containment within the open pit be lost upon pit flooding. While Figure 5-4 of the EIS demonstrates that some degree of water table drawdown around the open pit is maintained during the post closure period, this shallow 2D assessment is not sufficient to assess hydraulic containment. As such, the potential effect of backfilled tailings within the open pit is missing.
Information Request:	a. Complete particle tracking for the backfilled tailings within the Leprechaun open pit, and report on any discharge points for seepage. Integrate this volume of groundwater seepage into the assessment of the potential effects on fish and fish habitat down gradient of the open pit. b. Assess the sensitivity of the model results to the post-closure pit elevation and the presence of the fault.
Response:	a. Post-closure particle tracking for tailings located at the base of the Leprechaun open pit are presented on Figure IR-17.1. As shown on the figure, some of the particles within the Leprechaun pit are simulated to be discharged to Victoria Lake Reservoir (both south of tributary WP1 and north of NT2), while others remain within the open pit. The travel times associated with the particles that travel to the north are in excess of 2.3 million years, and the particles that travel to the south are in excess of 4.4 million years. Therefore, the discharge of these seepage rates is not anticipated to adversely affect the water quality in the receptors. b. The ultimate stage of the pit lake presented in the EIS represents the overflow depth; therefore, water levels are not anticipated to vary substantively around this level post-closure. As a result, a sensitivity

ID:	**IR-17**
	analysis of the post-closure modelling results was not warranted to evaluate this effect. c. The sensitivity of the particle tracks originating at the in-pit tailings was conducted. As shown by comparing Figures IR-13.13 and IR-13.14 to Figure IR-17.1, the ultimate destination of the particle tracks originating at the Leprechaun open pit are not altered by the presence of the fault, and do not indicate flow along the fault. The predicted travel times remain in excess of two million years.
Appendix:	None

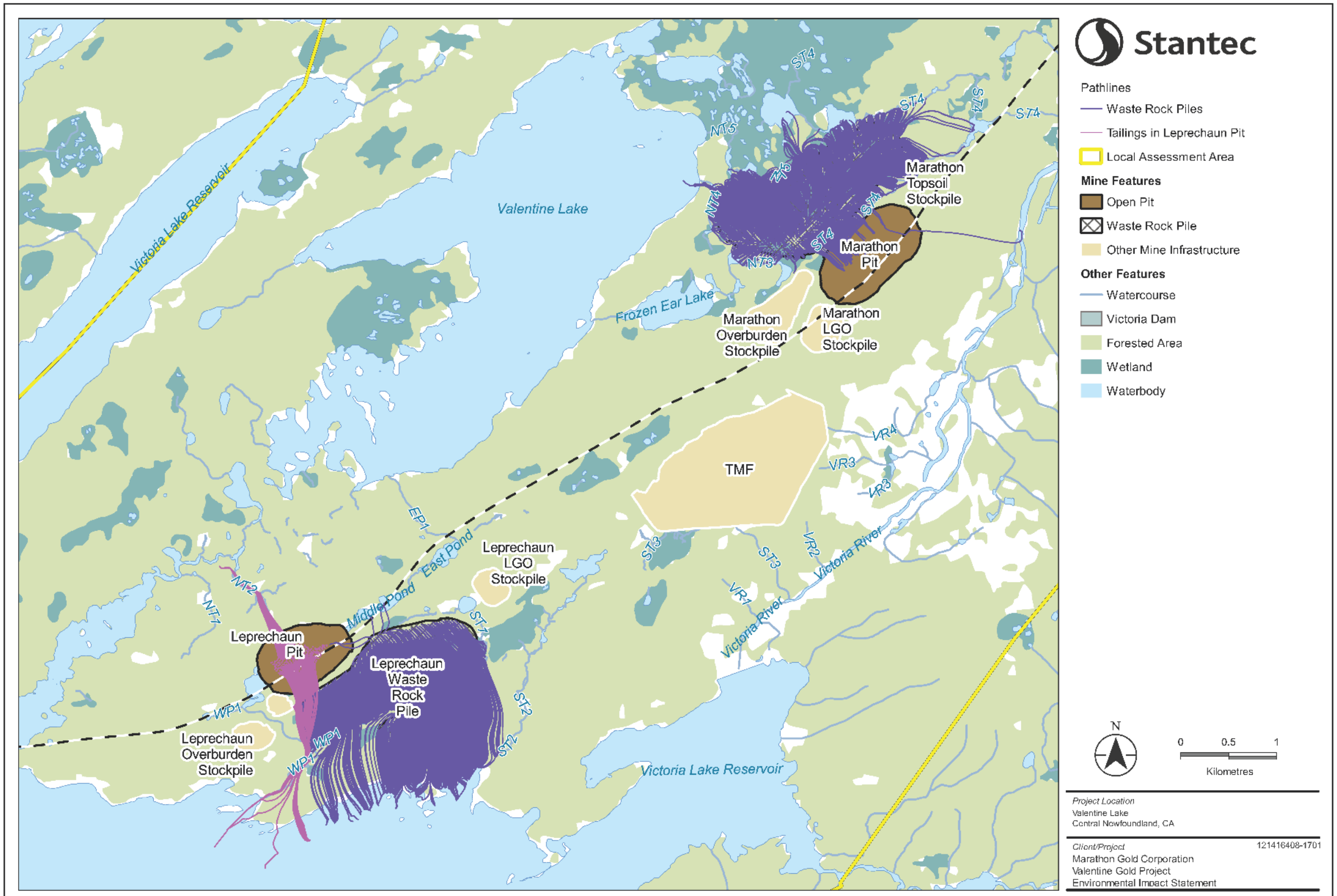

Figure IR-17.1 **Post-closure particle tracking for tailings located at the base of the Leprechaun open pit**

RESPONSE TO IR-18

ID:	**IR-18**
Expert Department or Group:	NRCan-13
Guideline Reference:	Section 7.1.2
EIS Reference:	Baseline Study Appendix 5 Attachment 5-B Section 3.1.1, 4.1.1, and 4.3.1 and Appendix A
Context and Rationale:	The EIS Guidelines require the proponent to complete a geochemical characterization of waste rock, ore, low grade ore, and overburden in order to predict metal leaching and acid rock drainage. It also refers the proponent to the MEND (2009). Geochemical samples collected from ore, low grade ore, and waste rock were presented on two plan views (ESI - Appendix A Figures A.4 and A.7) and four cross sections (EIS - Appendix A Figures A.5, A.6, A.8, A.9). These figures do not meet the guidance provided in MEND (2009), and do not adequately present the spatial distribution of all ore, low grade ore, and waste rock samples collected as part of this study. The mine rock sample interval length ranged from 1.0-1.5 m, which is shorter than that recommended in the MEND (2009) guidance document. Additionally, short sample intervals can be skewed by potential mineralogical heterogeneity across a geological unit and thus may not be representative of the overall composition of the geological unit. MEND (2009) provides a recommended minimum sampling frequency per waste rock lithology, where the final sample number must be determined based on site- specific conditions, study objectives, and the overall tonnage of each lithology to be mined. Tonnage estimates by waste rock lithology were not provided in baseline study appendix (BSA)-5 to demonstrate that the number of samples collected per lithology are sufficient for each of the main waste rock lithologies to be mined. The approximate proportions of some waste rock lithologies are stated in BSA-5; however, this does not reflect the overall tonnage of material.
Information Request:	a. Provide images (e.g., cross sections or block model images) that show the location of all ore, low grade ore, and waste rock samples from both Leprechaun and Marathon deposits. Also, provide maps of overburden sample locations from both deposits. b. Describe sample heterogeneity with respect to mineralogy and sample observations in the field to justify the short sample interval utilized in this study. Include an evaluation of exploration assay data to support this discussion. c. Provide tonnage estimates for each waste rock, low grade ore, and ore lithology from both the Leprechaun and Marathon deposits, and

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	quantitative justification for the number of samples collected to date. Include a plan to address data gaps.
Response:	a. Based on recent consultation with NRCan, it is understood that NRCan is requesting all samples be shown on cross-sections. In response, updated maps and cross-sections showing all samples are provided in Appendix IR-18.A. As well, overburden sample locations are provided on Figure IR-18.1. b. The approach taken in Marathon's geochemical characterization program is based on the geological interpretation and understanding of the gold mineralization and distribution / association of sulphide minerals specific to the deposits. Based on the mineralization characteristics at the Valentine Gold Project, the one-meter sample interval is considered appropriate for evaluating the variability in geochemistry and mineralogy of materials and capturing appropriately the natural variability in distribution of Acid Rock Drainage/Metal Leaching (ARD/ML) properties of the mine rock. An example of the selection table for drill hole MA-18-281 is shown in Table IR-18.1. The gold content is different in the sampled intervals (i.e., 84-85, 142-143, 203-204, 286-287, 362-363) as compared to the adjacent 1 m; this indicates variability in mineralization of the deposit. Longer sample intervals or compositing samples will mask the variability in material properties as indicated on page 8-9 of Mine Environment Neutral Drainage (MEND) Manual (2009). c. The tonnage estimates and number of samples tested are provided in Tables IR-18.2 and IR-18.3 for each lithology identified within the geologic block model. Some lithologies, such as mafic dykes and varieties of quartz porphyry are narrow and are therefore not represented in the block model based on the block sizes; these have been lumped in with larger geologic units containing these lithologies in models for both deposits. Additional sampling and testing of units with low mineralization is required, such as the gabbro and metasediments, which were not as well covered by exploration drill programs targeting gold anomalies. Overall, gold mineralization correlates with sulphide content indicating that undersampled lithological units are likely to have lower ARD/ML potential. Therefore, additional sampling and testing of these units is expected to result in an increase in the estimated tonnage of non-potentially acid generating rock. The additional sampling and testing targets, according to MEND (2009) are presented in Tables IR-18.2 and IR-18.3.

ID:	**IR-18**
	Reference: Mine Environment Neutral Drainage Program (MEND). 2009. Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials, MEND Report 1.20.1, p. 1-579.
Appendix:	Appendix IR-18.A

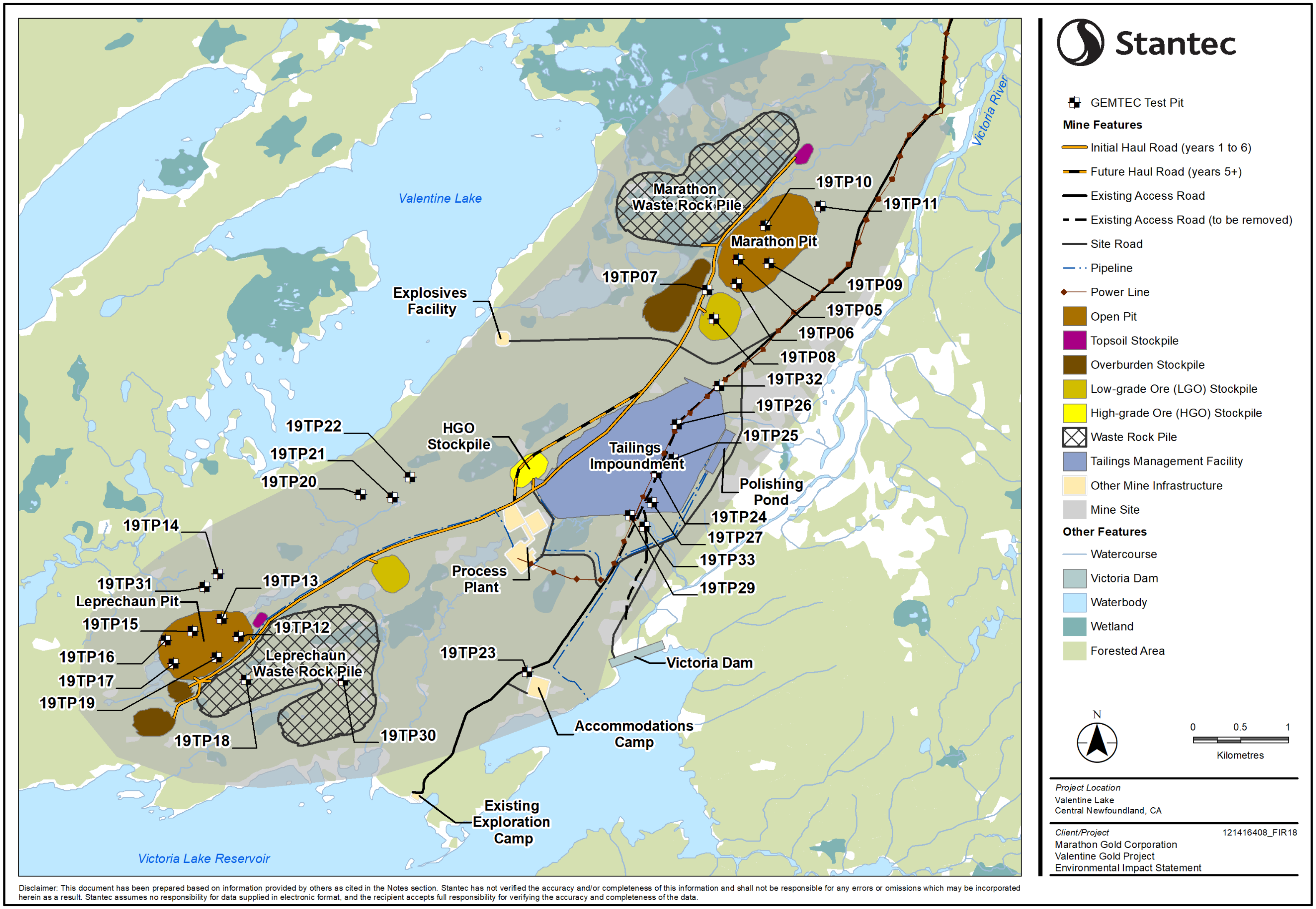

Figure IR-18.1 **Overburden Sample Locations**

Table IR-18.1 Logs and Assays of MA-18-281 Drill Hole used for Sample Selection.

Hole_ID	From_m	To_m	Au g/t	Lithology
MA-18-281	2.89	4		Conglomerate
MA-18-281	6	7		Conglomerate
MA-18-281	7	9	0.005	Mafic Dike
MA-18-281	9	11	0.005	Qtz-eye Porphyry
MA-18-281	11	13	0.009	Qtz-eye Porphyry
MA-18-281	13	15	0.015	Qtz-eye Porphyry
MA-18-281	15	17	0.005	Qtz-eye Porphyry
MA-18-281	17	19	0.022	Qtz-eye Porphyry
MA-18-281	19	21	0.060	Qtz-eye Porphyry
MA-18-281	21	23	0.011	Mafic Dike
MA-18-281	25	27	0.005	Aphanitic Qtz Porphyry
MA-18-281	27	29	0.005	Aphanitic Qtz Porphyry
MA-18-281	29	30	0.023	Aphanitic Qtz Porphyry
MA-18-281	30	31		Aphanitic Qtz Porphyry
MA-18-281	31	33	0.005	Qtz-eye Porphyry
MA-18-281	49	50	0.010	QZ - Qtz-eye Porphyry + QTP
MA-18-281	52	53	0.005	Qtz-eye Porphyry
MA-18-281	53	54	0.005	Qtz-eye Porphyry
MA-18-281	54	56	0.005	Qtz-eye Porphyry
MA-18-281	56	58	1.027	Qtz-eye Porphyry
MA-18-281	58	60	0.023	Qtz-eye Porphyry
MA-18-281	60	61	0.005	Qtz-eye Porphyry
MA-18-281	61	62	0.005	Qtz-eye Porphyry
MA-18-281	62	64	0.005	Qtz-eye Porphyry
MA-18-281	64	66	1.141	Aphanitic Qtz Porphyry
MA-18-281	68	70	0.005	Qtz-eye Porphyry
MA-18-281	82	83	0.016	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	83	84	0.005	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	84	85	0.123	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	85	86	0.341	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	86	87	0.005	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	87	88	0.005	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	88	89	0.135	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	89	90	0.083	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	90	91	0.005	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	91	92	0.005	Qtz-eye Porphyry
MA-18-281	94	96	0.005	Aphanitic Qtz Porphyry
MA-18-281	102	104	0.005	Qtz-eye Porphyry
MA-18-281	122	124	0.005	Aphanitic Qtz Porphyry
MA-18-281	134	136	0.012	Qtz-eye Porphyry
MA-18-281	136	138	0.069	Qtz-eye Porphyry
MA-18-281	138	139	0.201	Qtz-eye Porphyry
MA-18-281	139	140	1.091	Qtz-eye Porphyry
MA-18-281	140	141	0.526	Qtz-eye Porphyry
MA-18-281	141	142	2.028	Qtz-eye Porphyry
MA-18-281	142	143	0.504	Qtz-eye Porphyry
MA-18-281	143	145	0.724	Qtz-eye Porphyry
MA-18-281	145	147	0.015	Aphanitic Qtz Porphyry
MA-18-281	155	157	0.005	Qtz-eye Porphyry
MA-18-281	170	172	0.005	Aphanitic Qtz Porphyry

Note: Intervals highlighted in grey were selected for ARD/ML Testing Program

Table IR-18.1 Logs and Assays of MA-18-281 Drill Hole used for Sample Selection.

Hole_ID	From_m	To_m	Au g/t	Lithology
MA-18-281	172	173	0.005	Aphanitic Qtz Porphyry
MA-18-281	173	174	0.005	Aphanitic Qtz Porphyry
MA-18-281	174	176	0.005	Aphanitic Qtz Porphyry
MA-18-281	176	177	0.005	Aphanitic Qtz Porphyry
MA-18-281	177	178	0.005	Aphanitic Qtz Porphyry
MA-18-281	178	179	0.005	Qtz-eye Porphyry
MA-18-281	191	193	0.005	Aphanitic Qtz Porphyry
MA-18-281	197	199	0.005	Qtz-eye Porphyry
MA-18-281	200	201	0.005	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	201	202	0.005	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	202	203	0.005	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	203	204	0.019	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	204	205	0.014	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	205	206	0.019	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	206	207	0.039	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	207	208	0.005	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	208	209	0.005	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	209	210	0.005	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	210	211	0.005	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	211	212	0.005	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	212	213	0.005	Qtz-eye Porphyry
MA-18-281	218	220	0.005	Aphanitic Qtz Porphyry
MA-18-281	228	230	0.011	Qtz-eye Porphyry
MA-18-281	230	232	0.005	Qtz-eye Porphyry
MA-18-281	232	233	0.005	Qtz-eye Porphyry
MA-18-281	233	235		Qtz-eye Porphyry
MA-18-281	234	236	0.005	Qtz-eye Porphyry
MA-18-281	236	238	0.005	Qtz-eye Porphyry
MA-18-281	238	240	0.005	Qtz-eye Porphyry
MA-18-281	240	242	0.005	Qtz-eye Porphyry
MA-18-281	242	244	0.005	Qtz-eye Porphyry
MA-18-281	244	246	0.016	Qtz-eye Porphyry
MA-18-281	246	248	0.005	Qtz-eye Porphyry
MA-18-281	248	250	0.012	Qtz-eye Porphyry
MA-18-281	250	252	0.005	Qtz-eye Porphyry
MA-18-281	252	254	0.005	Qtz-eye Porphyry
MA-18-281	254	256	0.005	Qtz-eye Porphyry
MA-18-281	256	258	0.005	Aphanitic Qtz Porphyry
MA-18-281	262	264	0.005	Qtz-eye Porphyry
MA-18-281	282	284	0.005	Mafic Dike
MA-18-281	284	286	0.005	Mafic Dike
MA-18-281	286	287	0.012	Mafic Dike
MA-18-281	287	288	0.012	Mafic Dike
MA-18-281	288	290	0.005	Mafic Dike
MA-18-281	290	292	0.005	Mafic Dike
MA-18-281	292	294	0.005	Mafic Dike
MA-18-281	294	296	0.005	Mafic Dike
MA-18-281	296	298	0.005	Mafic Dike
MA-18-281	298	300	0.005	Mafic Dike
MA-18-281	300	302	0.005	Mafic Dike
MA-18-281	302	304	0.005	Mafic Dike
MA-18-281	304	306	0.005	Aphanitic Qtz Porphyry

Note: Intervals highlighted in grey were selected for ARD/ML Testing Program

Table IR-18.1 Logs and Assays of MA-18-281 Drill Hole used for Sample Selection.

Hole_ID	From_m	To_m	Au g/t	Lithology
MA-18-281	318	320	0.005	Qtz-eye Porphyry
MA-18-281	324	326	0.005	Mafic Dike
MA-18-281	342	344	0.007	Qtz-eye Porphyry
MA-18-281	344	346	0.007	Qtz-eye Porphyry
MA-18-281	346	348	0.008	Qtz-eye Porphyry
MA-18-281	348	350	0.007	Qtz-eye Porphyry
MA-18-281	350	352	0.026	Qtz-eye Porphyry
MA-18-281	352	354	0.050	Qtz-eye Porphyry
MA-18-281	354	356	0.009	Qtz-eye Porphyry
MA-18-281	356	357	0.005	Qtz-eye Porphyry
MA-18-281	357	358	0.005	Qtz-eye Porphyry
MA-18-281	358	359	0.060	Qtz-eye Porphyry
MA-18-281	359	360	0.005	Qtz-eye Porphyry
MA-18-281	360	361	0.005	Qtz-eye Porphyry
MA-18-281	361	362	0.006	Qtz-eye Porphyry
MA-18-281	362	363	0.014	Qtz-eye Porphyry
MA-18-281	363	364	0.019	Qtz-eye Porphyry
MA-18-281	364	365	0.007	Qtz-eye Porphyry
MA-18-281	365	367	0.005	Qtz-eye Porphyry
MA-18-281	367	369	0.005	Qtz-eye Porphyry
MA-18-281	369	371	0.005	Qtz-eye Porphyry
MA-18-281	371	373	0.005	Qtz-eye Porphyry
MA-18-281	373	375	0.007	Qtz-eye Porphyry
MA-18-281	375	377	0.005	Qtz-eye Porphyry
MA-18-281	377	379	0.005	Qtz-eye Porphyry
MA-18-281	379	381	0.005	Qtz-eye Porphyry
MA-18-281	381	383	0.005	Qtz-eye Porphyry
MA-18-281	383	385	0.005	Qtz-eye Porphyry
MA-18-281	385	387	1.229	Qtz-eye Porphyry
MA-18-281	387	388	0.038	QZ - Qtz-eye Porphyry + QTP
MA-18-281	395	396	0.309	Qtz-eye Porphyry
MA-18-281	402	403	0.088	QZ - Qtz-eye Porphyry + QTP
MA-18-281	408	409	1.200	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	409	410	0.026	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	410	411	5.069	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	411	412	0.007	QZ - Qtz-eye Porphyry + Minor QTP
MA-18-281	412	413	0.219	QZ - Qtz-eye Porphyry + QTP
MA-18-281	413	414	0.107	QZ - Qtz-eye Porphyry + QTP
MA-18-281	414	415	0.251	QZ - Qtz-eye Porphyry + QTP
MA-18-281	415	416	0.196	QZ - Qtz-eye Porphyry + QTP
MA-18-281	416	417	2.454	QZ - Qtz-eye Porphyry + QTP
MA-18-281	417	418	0.584	QZ - Qtz-eye Porphyry + QTP
MA-18-281	418	419	0.114	QZ - Qtz-eye Porphyry + QTP
MA-18-278	10.51	12	0.005	Qtz-eye Porphyry

Note: Intervals highlighted in grey were selected for ARD/ML Testing Program

Table IR-18.2 Tonnages of lithological units from geological block model and numbers of samples per unit for the Marathon Deposit

Block Model Lithology	Material type	Tonnage, Mt	# of samples tested to date	Suggested initial frequency per Table 8-2, MEND 2009	# of additional of samples to be tested per Table 8-2 MEND 2009
Metasediments	Waste Rock	30.3	9	80	71
Gabbro	Waste Rock	8.0	4	26	22
QEPOR	Waste Rock	106.7	125	80	0
High Grade Ore	Ore	14.6	28	80	52
Low Grade Ore	Ore	11.1	15	80	65
Overburden	Waste	7.5	14	26	12

Table IR-18.3 Tonnages of lithological units from geological block model and numbers of samples per unit for the Leprechaun Deposit

Block Model Lithology	Material type	Tonnage, Mt	# of samples tested to date	Suggested initial frequency per Table 8-2, MEND 2009	# of additional of samples to be tested per Table 8-2 MEND 2009
Metasediments	Waste Rock	33	21	80	59
Trondhjemite	Waste Rock	105	93	80	0
High Grade Ore	Ore	8.6	24	26	2
Low Grade Ore	Ore	6.7	13	26	13
Overburden	Waste	3.8	6	26	20

RESPONSE TO IR-19

ID:	**IR-19**
Expert Department or Group:	NRCan-14 MFN-08 ECCC-24
Guideline Reference:	Section 7.2.2
EIS Reference:	Baseline Study Appendix 5 Attachment 5-A and 5- B
Context and Rationale:	The EIS Guidelines require the proponent to complete a geochemical characterization of potential construction material in order to predict acid rock drainage and metal leaching (ARD/ML). A geochemical characterization study must be completed for all construction materials to evaluate their suitability related to ARD/ML. The potential use of waste rock, overburden, and/or quarry material was not discussed in BSA-5, nor was the suitability of waste rock and overburden materials for construction use. Section 6.3.5.3 of the EIS states that the overburden at the Leprechaun and Marathon pits has the potential to leach a number of parameters including aluminum, arsenic, cadmium, copper, fluoride, iron, manganese, lead, selenium and zinc. It goes on to state that the waste rock pile will be covered by growth medium / overburden during rehabilitation, further reducing the risk of acid rock drainage and metals leaching. Table 6.4 in Section 6.4 of the EIS states that progressive rehabilitation will be implemented involving placement of a soil cover and vegetation. However, it is not explained how this will improve conditions at the site if overburden which is leaching metals is used. Section 6.3.5.4 of the EIS states that groundwater mass loadings were calculated based on the geochemical source terms for the ore stockpiles, waste rock piles, and tailings management facility seepage; however, groundwater mass loadings were not calculated for overburden. Section 6.3.5.3 of the EIS states that investigations of acid rock drainage and metals leachate will continue and will include field and laboratory kinetic testing and additional sampling to develop an ARD model. Section 6.0 of BSA 5A states that “Tailings from Leprechaun deposits, are expected to be non-PAG and have excess of NP. This excess of NP can be used to offset ARD potential of tailings from Marathon if ores from Marathon and Leprechaun deposit are processed at the same time and mixed. Therefore, the mixed tailings are not expected to show ARD potential, unless Marathon ore is processed separately from Leprechaun ore and resulting solids are left exposed after the closure. Section 5.2.2 of BSA 5A states that “approximately 14% of the waste rock from the Marathon pit is conservatively estimated to be PAG. Blending PAG and non-PAG rock with excess of neutralization potential and/or encapsulation of PAG waste by non-PAG rock is recommended to neutralize acidity potentially generated in PAG pockets.”

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Information Request:	a. Provide a geochemical characterization of the ARD/ML potential of all materials planned to be used for construction purposes. Include quarries, if applicable. b. Explain how covering the waste rock pile with overburden that is leaching up to ten metals parameters would result in a reduction of metals leaching when covering waste rock. c. Clarify if overburden which is metals leaching will be used for the soil cover. Update the effects analysis and mitigation measures, as appropriate, if overburden leaching metals is proposed to be used on site. d. Given that multiple metals parameters have the potential to leach from overburden, provide a groundwater mass loading for overburden stockpiles or provide a rationale why the overburden was excluded from this analysis. e. Update the analysis of the acid rock drainage and metals leachate investigations if more recent data is available. f. With regard to plans to manage ARD for this project, confirm that mitigation measures (e.g., blending to maintain Neutralization Potential Ratios) to avoid ARD generation will be employed when waste rock is used in onsite infrastructure (e.g., road beds).
Response:	a. It is currently planned that nearly all earthworks construction will utilize waste rock developed from the open pits. All bulk earthworks, including roads, building and stockpile pads, embankments for ditching and water management ponds and dams for the Tailings Management Facility (TMF) will be constructed using waste rock. It is also planned to crush and screen non-potentially acid generating (PAG) waste rock for more detailed earthworks. The waste rock has been characterized as described in Section 5.2 of Valentine Gold Project: Acid Rock Drainage/Metal Leaching (ARD/ML) Assessment Report (BSA-5 in the EIS). This report provided the basis for distinguishing between PAG and non-PAG rock, and further testing will be completed as described in Appendix IR-19.A. Additional testing will be completed during excavation of waste rock materials from the open pits for use in construction, as required to ensure that only non-PAG rock is used. It is expected that a relatively small amount of quarried rock will be required to commence construction, prior to waste rock being available from the open pits, to develop temporary access roads and construction laydown areas. As part of the advancing engineering for the Project, Marathon will be investigating several potential quarry sites that exist within the footprints of future mine infrastructure (e.g., the Leprechuan

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	waste rock pile area) in order to minimize environmental impacts overall. Any potential quarry sources will be sampled and geochemical testing completed as part of this investigation and prior to use in earthworks. Additionally, some overburden (glacial till) materials will be used in small amounts for embankment construction for water management infrastructure. The geochemical characterization of these materials is addressed in part b), below. The only construction material not sourced to date is sand for concrete. The current plan is to source sand from local suppliers who have existing sand quarries; alternatively, non-PAG waste rock will be crushed and screened to provide the sand required. b/c. The overburden is glacial till, which originates from distant locations (based on the glacial history of the site) and was not generated from weathering of Project ore deposits. Covering of the waste rock pile with overburden will reduce advective transport of oxygen to the internal portion of the pile resulting in less sulphide oxidation and metal leaching from the waste rock. The current water quality model includes metal leaching from the overburden cover (Appendix 7A and 7B of the EIS). As a result, the assessment of the effects of metal leaching from overburden has already been considered in the EIS. d. Natural groundwater is already in “dynamic” equilibrium with metals leaching from the vadose zone of overburden with the baseline groundwater chemistry reflecting natural metal leaching from unsaturated overburden into groundwater. This statement is supported by baseline groundwater samples from the overburden showing exceedances of Aluminum, Arsenic, Cadmium, Iron, Manganese, and Zinc, which is similar to the list of metal exceedances observed in Shake Flask Extraction testing of overburden samples (Table C-3 of Appendix 7B and Table B-18 of BSA-5 in the EIS). Based on the concurrence of these observations, the assumption that groundwater quality under overburden will stay similar to baseline conditions is reasonable. Therefore, addition of mass loading from exposed overburden to groundwater is not required. e. Marathon recognizes that further ARD/ML work is required and further assessment and associated refinement of Project mitigation as design of the Project proceeds (refer to Appendix IR-19.A for further information). Specifically, Marathon is committed to completing additional work to address testing gaps identified in the program completed to date, and as noted by NRCan, within the next 6 to 8

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	months and prior to construction. This information is required for final design and permitting under the NL *Mines Act* (NL Department of Industry, Energy, and Technology), and will be shared with NRCan as it becomes available: Specifically, Marathon is committed to completing the following additional work within the indicated timeframes: 1. Continue collection of results from on-going laboratory and field tests in 2021. This work was started in 2020 and will continue until concentrations stabilize. It is expected that updated analysis will be conducted in Q4 of 2021. 2. Additional static testing of samples in Q2 and Q3 of 2021 3. Initiate additional kinetic testing of PAG materials (waste rock, ore and low-grade ore) from major lithologies of the Marathon pit and composite sample of gabbro in Q2 of 2021. f. As described in the response to part a), above, only non-PAG rock will be used in earthworks construction for the Project.
Appendix:	Appendix IR-19.A

RESPONSE TO IR-20

ID:	**IR-20**
Expert Department or Group:	NRCan-15
Guideline Reference:	Section 7.1.2
EIS Reference:	Baseline Study Appendix 5 Attachment 5-B Appendix B and C
Context and Rationale:	The EIS Guidelines require the proponent to complete a geochemical characterization of the expected mine materials in order to predict acid rock drainage and metal leaching (ARD/ML). As indicated in the EIS Guidelines, the MEND (2009) guidance document recommends presenting geochemical test results in tabulates with descriptive statistics, as well as in scatter plots and time series graphs. A complete set of tabulated static test results grouped by lithology and including sample descriptions was not provided for all samples tested. Further, statistics provided in Appendix B Tables of the EIS present results that do not follow basic principles. For example, the Appendix B Tables provide average concentrations that are outside of the minimum and maximum range. Without a complete set of tabulated data, it is not possible to complete the ARD/ML review in terms of evaluating the variability in sample chemistry across each lithology, nor to confirm the validity of the statistical distribution of results. Additionally, a complete set of tabulated kinetic test results for each humidity cell, subaqueous column, and ageing test was not provided in Appendix B, and time series graphs were only provided for select parameters in Appendix C. As such, the long-term evolution and change in leachate quality cannot be evaluated for all parameters.
Information Request:	a. Present updated versions of Appendix Table B-5 and B-17 with the correct statistical calculations recommended in the MEND guidance. b. Provide a complete set of tables for each static test completed for waste rock, low grade ore, and ore by rock type. c. Provide updated statistics in Appendix Tables B-6, B-7, B-18 and B-19 that provide corrected average concentrations and enable the confirmation of the validity of the statistical distribution of results. d. Provide tables and time series graphs for each humidity cell, subaqueous column, and ageing tests for all tested parameters.
Response:	a. Tables B-5, B-17, B-6, B-7, B-18 and B-19 have been reviewed to confirm that the statistical calculations are correct. Average Neutralization Potential Ratio (NPR) values are sometimes outside of the minimum and maximum NPR range for some lithologies because

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	the value of NPR reported as “average” was calculated as the ratio of average Neutralization Potential (NP) and average acid potential (AP), not as the average of individual NPRs. Averaging of ratios would provide misleading results generally showing higher NPR values in this Project. b. An Excel file containing all static tests, which are classified by material (such as rock, ore) and/or lithology, will be provided directly to NRCan. Tables in pdf format containing all static test results for all samples were initially provided in analytical reports compiled in Appendix D of Attachment 5-B of the EIS. c. Please refer to (a) above. d. It is acknowledged that only parameters having an applicable regulatory threshold (*Metal and Diamond Mining Effluent Regulations* limit or/and Canadian Water Quality Guideline for Protection of Freshwater Aquatic Life) were selected for assessment and plotting in Appendix C of Attachment 5-B of the EIS. Sulphate, as an indicator of sulphide oxidation, was also plotted and presented. Time-series graphs are provided in Appendix IR-20.A for constituents with concentrations greater than the detection limit. A complete kinetic database will be provided directly to NRCan in the form of an Excel file for evaluation of leachate quality for all parameters.
Appendix:	Appendix IR-20.A

RESPONSE TO IR-21

ID:	**IR-21**
Expert Department or Group:	NRCan-16
Guideline Reference:	Section 7.2.2
EIS Reference:	Baseline Study Appendix 5 Attachment 5-B Section 3.1.2, 3.2.2,3.2.3, 4.0, 5.0Chapter 7 Appendix 7A and 7B
Context and Rationale:	The EIS Guidelines require the proponent to evaluate the longer term rates of acid generation and metal leaching, estimates of the potential time to onset of acid rock drainage or metal leaching (ARD/ML), and the quantity and quality of leachate from samples of tailings, waste rock, and ore. These leachate compositions are then used in the water quality model to evaluate the quality of effluent to be released from the site into receiving waters. The EIS Guidelines refer to the MEND (2009) guidance document. The guidance document indicates that samples selected for kinetic testing must be conservatively representative of the lithology they represent, taking into consideration mineralogy, ARD potential, metal/metalloid content, and leaching potential, and documented in the MEND (2009) guidance document. Composite samples were developed to represent low-grade ore, waste rock, and tailings, and were subjected to laboratory static tests, mineralogy, and humidity cell tests to evaluate long-term ARD/ML potential and timing to onset of ARD. A detailed quantitative rationale was not provided to demonstrate that the composite samples are conservatively representative of the overall chemical composition of their respective waste rock lithologies for ARD/ML parameters of concern. Therefore, it is not possible to determine whether the humidity cell test results are a conservative representation of weathering rates for the tested material, and thus appropriately conservative for use as source terms for the water quality models to evaluate the potential future effluent quality related to ARD /ML and neutral mine drainage (NMD). This information is important for decision making regarding management of waste rock, low grade ore, and exposed pit walls, as well as water management and treatment. All composite samples are non-acid generating based on neutralization potential ratio (NPR) values less than 2 (Table 5-2 and Appendix Table B-8), despite approximately 14% of waste rock at Marathon having been classified as potentially acid generating (PAG) based on samples tested and reported to date. This does not meet the MEND (2009) guidance to design a kinetic test program that includes material that will produce problematic drainage chemistry in terms of ARD/ML, even if this material is a lower anticipated waste volume than other units. Further, the timing to

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	onset of acidic conditions was estimated based on mineral depletion calculations using sulphate and alkalinity production rates associated with the dissolution of soluble secondary salts rather than sulphate production from sulphide mineral oxidation. Due to the absence of any evidence of active sulphide mineral oxidation in the tests completed to date, these time estimates are not considered reasonable to support assumptions in the water quality model related to the timing of ARD for low grade ore and waste rock, nor decisions related to waste rock management. Lastly, the metal leaching potential under acidic conditions has not been captured in the humidity cell tests completed on non-acid generating samples to date, which has implications for the source terms and assumptions that were made in the water quality models (Chapter 7 Appendix 7A and 7B) to represent acidic drainage quality from the pit walls and waste rock piles. Therefore, it is not possible to confirm that humidity cell test leachate on potentially acid generating samples would maintain leachate concentrations below MDMER limits. A complete understanding of the risk and extent of ARD and metal loading is required to appropriately manage PAG waste and exposed PAG rock in the pit walls, as well as water management and treatment planning. Therefore, the potential development of ARD in pockets of the waste rock pile or the pit walls has not been sufficiently evaluated to support the assumptions made in the water quality model related to the maintenance of neutral contact water in the ponds below the waste rock and low grade ore stockpiles and captured pit wall runoff.
Information Request:	a. Provide a quantitative rationale for the targeted chemistry of each composite sample used for kinetic testing with respect to the lithology that they represent and percentile rankings for all parameters of interest with respect to ARD-NMD/ML. b. Provide a detailed plan to test potentially acid generating samples from those lithologies identified as containing potentially acid generating material, including static, mineralogy, and kinetic tests. c. Provide rationale for the methods used to determine the lag time to acidic conditions, and a discussion around the sensitivity of the water quality model to the assumptions related to this assumed lag time. d. Provide rationale for assumptions in the water quality model related to the metal load associated with acidic drainage. Complete a sensitivity analysis related to the assumed metal load for potentially acid generating material, including but not limited to the ore, low grade ore, and waste rock piles, and the pit walls. e. Discuss the sensitivity of water quality model predictions in relation to the conservatism of the source terms.

ID:	**IR-21**
Response:	a. Composite samples of major lithologies were used for kinetic testing. The composite samples were prepared for each lithology using crushed residual material from individual samples used in the second phase of the Acid Rock Drainage/Metal Leaching (ARD/ML) program. The residual materials were mixed in approximately the same proportions to produce a composite sample representative of the average composition of each lithology. Tables IR-21.1 to IR-21.4 provide a quantitative comparison of parameters measured in the composite to select statistics (average, median and 25th percentile) determined from results of individual samples of the same lithology. The summary tables demonstrate that the majority of parameters of potential concern in composite samples (Table 5-1 of Attachment 5-B of the EIS) have an equal or greater value than the average or/and median reported for the lithology. Therefore, the composite samples generated for kinetic tests are considered representative of each lithology. b. Kinetic testing of potentially acid generating (PAG) samples are anticipated to take years before the neutralization potential (NP) is depleted and acidic leachate is generated. To reduce the testing time, humidity cells were started on a carbonate-depleted tailings from Marathon ore (Sample CND-1) and on low grade ore (sample MLGO-Met) from Marathon in August of 2020. Carbonate depletion transforms material into PAG, prior to testing. The results of these tests are presented in the Appendix IR-21.A and were used for development of the water quality model as discussed in part d) of this response (below). Additional kinetic testing of PAG materials (waste rock, ore and low-grade ore) from major lithologies of the Marathon pit and a composite sample of gabbro material will be started in Q2 of 2021. These samples will be submitted for static tests including net acid generating (NAG) tests, mineralogy and particle size distribution similar to the characterization of composite samples described in Attachment 5-B of the EIS. The results of this test work will be included in the ARD/ML Management Plan (see Appendix IR-19.A) which will be provided to NRCan, for review and comment. c. The discussion on rationale for the methods used to determine the lag time to acidic conditions and estimate on the possible ranges of ARD onset lag time for exposed PAG materials is provided in the Appendix IR-21.B. d. In the Marathon water quality model, the leaching rates for acidic conditions were considered as stated in the last paragraph of Section 5.3.1.1 in Appendix 7B of the EIS. “All leaching rates are obtained from

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	neutral drainage because none of the geochemical tests have developed acidic leachate. However, samples of some lithologies are expected to generate acidic drainage resulting in an increase in metal leaching in localized zones of PAG materials. In order to account for this increase, neutral leaching rates are inflated by factors of 11.9 for Zinc, 7.5 for Nickel, 3.5 for Iron, 1.8 for Cadmium, 1.6 for Lead 1.2 for Copper, 1.1 for sulphate in PAG rock mass at ARD onset time. These inflation factors were estimated as a ratio of first-month leaching from carbonate depleted humidity cell containing Marathon LGO to the same rates from the initial (non-depleted) sample for LGO.” The range of acidic rates was accounted for in the GoldSim water quality model through probabilistic inputs of ARD onset time and variability of neutral leaching rate. An example of the resulting probability distribution for acidic term for copper is shown on Figure IR-21.1. Sensitivity analyses related to the effect of ARD onset to metal load for potentially acid generating material for low grade ore and waste rock piles, and the pit walls is presented in Appendix IR-21.B. e. The source terms, such as leaching rates, ARD onset times, scaling factors and concentrations in solutions were treated as probabilistic inputs in the water quality model (Section 5.3.1 in Appendix 7B of the EIS). These inputs included very conservative values, such as maximum laboratory leaching rate and shortest ARD onset time. Probabilistic combinations of conservative inputs produced conservative results for water quality as presented in the EIS. Additional discussion on the sensitivity of source terms is provided in Appendix IR-21.B. Reference: Mine Environment Neutral Drainage Program (MEND). 2009. Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials, MEND Report 1.20.1, p. 1-579.
Appendix:	Appendix IR-21.A and IR-21.B

Table IR-21.1 Comparison of ABA statistics for individual samples to composite samples (ID is in bold).

Parameter	S_{TOTAL}	$S_{SULPHATE}$	$S_{SULPHIDE}$	Carb. NP	AP	NNP	Carb. NPR
Units	**wt.%**			**kg $CaCO_3$/t**			
1. Trondhjemite and Granodiorite (TRJ), 54 samples							
25th, %ile	0.020	0.010	0.01	28.7	0.3	54	96
Median	0.035	0.010	0.02	36.6	0.6	61	59
Average	0.06	0.013	0.05	42.4	1.5	65	29
L TRJ	0.08	0.050	0.03	48.3	0.9	47	**51**
2. QZ - Trondhjemite + QTP and QZ - Granodiorite + QTP (QZ-TQTP), 33 samples							
25th, %ile	0.056	0.005	0.04	27.7	1.3	54	21
Median	0.110	0.010	0.09	36.1	2.8	65	13
Average	0.15	0.017	0.13	45.2	4.1	69	11
L QZ-QTP	0.11	0.050	0.06	44.7	1.9	43	24
3. Conglomerate and Sediments (CG and SED), 17 samples							
25th, %ile	0.003	0.010	0.01	5.0	0.3	13	17
Median	0.010	0.010	0.01	12.5	0.3	21	42
Average	0.01	0.015	0.01	15.0	0.4	28	38
L SED	< 0.005	< 0.02	< 0.02	9.2	0.6	8.6	**15**
5. Mafic Dike (MD), 19 samples							
25th, %ile	0.076	0.025	0.05	72.1	1.4	113	51
Median	0.120	0.040	0.06	125.7	1.9	171	66
Average	0.19	0.039	0.15	116.3	4.8	159	24
L MD	0.13	0.060	0.07	97.3	2.2	95	**44**
7. QZ-QTP, 3 samples							
25th, %ile	0.049	0.020	0.02	54.1	0.8	53	69
Median	0.068	0.030	0.03	69.8	0.9	69	74
Average	0.06	0.027	0.03	69.7	1.2	90	60
L QZ-QTP	0.05	0.030	0.02	51.6	0.62	51	83
8. Low-Grade Ore, 10 samples							
25th, %ile	0.096	0.010	0.08	15.4	2.5	27	6.1
Median	0.213	0.015	0.15	34.1	4.5	52	8
Average	0.25	0.039	0.22	45.4	6.8	67	7
L LGO	0.16	0.060	0.10	37.9	3.1	35	12
LLGO-Met	0.27	0.040	0.23	61.3	7.2	54	9

Notes:
S_{TOTAL} - Total Sulphur; $S_{SULPHIDE}$ - Sulphide Sulphur; $S_{SULPHIDE}=S_{TOTAL}-S_{SULPHATE}$; $S_{SULPHATE}$ - Sulphate Sulphur;
Carb. NP - Carbonate Neutralization Potential; Carb; $NP=TIC*M(CaCO_3)/M(C)*10$(kg/t from % diff.);
AP - Acid Potential; $AP=S_{SULPHIDE}(\%) \times 31.25$; NNP - Net Neutralization Potential; NPR - Neutralization Potential Ratio;
TIC - Total Inorganic Carbon. Respective samples from Phase I and II are combined.
Values in cells highlighted yellow exceed either median or average value for the material;
Values in cells highlighted green are between the 25th percentile and average value for the material.

Table IR-21.2 Comparison of trace element statistics for individual samples to composite samples (ID is in bold).

	Ag	Al	As	Be	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	P	Pb	Se	Tl	U	V	Zn
ACUCx10	530	407639	48	21	0.90	173	920	280	320415	0.5	774.5	11	470	654.3	170	0.9	9	27	970	670
Units	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
1. Trondhjemite and Granodiorite (TRJ), 54 samples																				
25th, %ile	0.050	6205	0.5	0.50	0.050	1.3	44	3.5	833	0.025	403	0.20	1.4	12	10.5	0.50	0.250	0.100	6.0	24
Median	0.050	6420	1.0	0.50	0.050	1.9	50	4.8	1025	0.025	465	0.30	1.7	14	12	0.50	0.25	0.20	9.0	32
Average	0.044	6323	1.4	0.59	0.044	3.5	53	8.3	2721	0.025	486	0.35	3.0	23	12	0.48	0.21	0.20	21	33
L TRJ	< 0.01	5600	0.8	0.12	0.030	3.3	54	6.9	12000	< 0.05	430	2.7	3.2	280	3.4	< 0.7	0.02	0.12	8.0	27
2. QZ - Trondhjemite + QTP and QZ - Granodiorite + QTP (QZ-TQTP), 33 samples																				
25th, %ile	0.050	6120	0.5	0.50	0.050	1.3	50	4.3	780	0.025	389	0.20	1.4	11.5	6.0	0.50	0.250	0.20	8.0	23
Median	0.050	6710	1.0	0.50	0.050	3.1	54	8.8	1180	0.025	446	0.30	1.7	18	8.7	0.50	0.25	0.30	10	33
Average	0.043	6674	1.1	0.69	0.049	3.8	55	14.1	3913	0.025	496	1.48	2.6	27	8.9	0.47	0.21	0.31	25	32
L QZ-TQTP	0.01	6300	0.8	0.13	0.030	4.0	59	10.0	13000	< 0.05	490	3.0	3.4	260	2.5	< 0.7	< 0.02	0.16	12.0	35
3. Conglomerate and Sediments (CG and SED), 17 samples																				
25th, %ile	0.005	6870	3.4	0.15	0.040	13.7	55	1.2	3690	0.025	773	0.05	20	67	1.1	0.35	0.010	0.53	41	65
Median	0.050	7250	5.0	0.50	0.050	15.2	68	3.9	4120	0.025	**877**	0.20	26	73	13	0.50	0.25	1.3	95	70
Average	0.037	9268	4.7	0.57	0.053	15.1	64	14.0	11032	0.025	**938**	0.74	24	75	10	0.46	0.18	1.1	81	69
L SED	< 0.01	14000	3.2	0.16	0.030	14.0	50	2.5	31000	< 0.05	750	0.8	24.0	810	1.2	< 0.7	0.02	0.47	46.0	61
5. Mafic Dike (MD), 19 samples																				
25th, %ile	0.050	7000	4.0	0.50	0.050	29.5	46	51.8	6580	0.025	**1060**	0.35	19.8	83	3.9	0.50	0.250	0.15	197	75
Median	0.050	7520	10	0.50	0.050	36.3	81	58.0	7570	0.025	**1400**	0.60	28	91	6.6	0.50	0.25	0.40	250	83
Average	0.041	11038	11	0.65	0.101	31.7	77	56.9	17397	0.025	**1264**	0.83	24	88	6.3	0.47	0.20	0.34	225	78
L MD	0.01	22000	2.2	0.17	0.070	29.0	70	50.0	59000	< 0.05	1100	1.1	22.0	610	2.0	< 0.7	< 0.02	0.12	170.0	70
7. QZ-QTP, 3 samples																				
25th, %ile	0.005	5100	1.4	0.13	0.010	3.6	55	5.6	5660	0.025	495	0.20	2.8	52	1.6	0.35	0.010	0.20	8.5	35
Median	0.005	6000	2.0	0.13	0.010	4.8	59	8.0	9900	0.025	530	0.20	3.5	52	1.7	0.35	0.01	0.20	12	36
Average	0.020	5403	1.9	0.42	0.023	4.2	60	16.7	9773	0.025	527	0.63	3.2	52	3.9	0.40	0.09	0.22	20	39
L QZ-QTP	< 0.01	5900	0.5	0.14	0.020	4.6	38	10.0	15000	< 0.05	460	1.9	3.2	440	1.6	< 0.7	< 0.02	0.17	11.0	42
8. Low-Grade Ore, 10 samples																				
25th, %ile	0.050	4780	1.10	0.16	0.043	3.8	61	8.0	1260	0.025	337	0.13	2.8	25	4.2	0.35	0.010	0.20	9.5	17
Median	0.050	6515	1.8	0.50	0.050	5.0	69	11.1	5975	0.025	414	0.40	4.3	39	6.4	0.50	0.25	0.22	23	33
Average	0.115	6547	2.2	0.45	0.048	10.5	81	42.1	10457	0.040	512	0.83	12	47	9.9	0.44	0.15	0.51	56	41
L LGO	0.03	4100	2.0	0.10	0.070	4.1	70	20.0	13000	< 0.05	340	1.7	5.3	390	1.8	< 0.7	< 0.02	0.15	8.0	26
LLGO-Met	0.04	5300	1.3	0.12	0.030	5.5	29	8.1	14000	0	430	0.8	3.8	-	7.3	< 0.7	< 0.02	0.80	8.0	33

Notes:

Respective samples from Phase I and II are combined.

ACUC - Average Concentration in the Upper Crust of the Earth based on Rudnick and Gao (2004); Values exceeding 10x the Average Concentration in the Upper Crust are double underlined and bold;

For the values less than Reportable Detection Limit (RDLs) values, 1/2 of RDLs are used to calculate statistical parameters.

Values in cells highlighted yellow exceed either median or average value for the material. Values in cells highlighted green are between the 25th percentile and average value for the material.

Table IR-21.3 Comparison of ABA statistics for individual samples to composite samples (ID is in bold).

Parameter	Paste pH	S_{TOTAL}	$S_{SULPHATE}$	$S_{SULPHIDE}$	Carb. NP	AP	NNP	Carb. NPR
Units	**pH Units**	**wt.%**			**kg $CaCO_3$/t**			
1. Qtz-eye Porphyry and Qtz-Porphyry Breccia (QE-POR and QE-POR-BX), 66 samples								
25th, %ile	9.39	0.018	0.010	0.01	23.2	0.6	24	37
Median	9.52	0.100	0.020	0.07	36.8	2.0	48	18
Average	9.47	0.17	0.051	0.12	48.4	3.9	61	13
M QE-POR	8.74	0.08	0.030	0.05	62.5	1.6	61	40
2. Aphanitic Qtz Porphyry (AQPOR), 19 samples								
25th, %ile	9.45	0.037	0.010	0.03	13.0	0.8	9	17
Median	9.69	0.076	0.030	0.05	18.5	1.6	22	12
Average	9.60	0.27	0.062	0.22	31.5	6.9	30	5
M AQPOR	9.48	0.33	0.090	0.24	48.6	7.5	41	6
3. Conglomerate (CG), 9 samples								
25th, %ile	9.36	0.003	0.010	0.01	75.2	0.3	75	251
Median	9.56	0.003	0.010	0.01	84.2	0.6	99	136
Average	9.50	0.01	0.009	0.01	101.1	0.5	116	212
M CG	9.53	< 0.005	< 0.02	< 0.02	87.3	0.6	87	141
5. Mafic Dike (MD), 19 samples								
25th, %ile	8.82	0.030	0.010	0.01	44.9	0.6	77	72
Median	9.03	0.090	0.030	0.04	93.3	1.3	105	72
Average	9.05	0.12	0.051	0.08	96.4	2.5	118	38
M MD	8.96	0.27	0.080	0.19	88.7	5.9	82.7	15
6. QZ - Qtz-eye Porphyry + Minor QTP (QZ-QE-POR-QTP-MIN), 10 samples								
25th, %ile	9.61	0.041	0.015	0.03	17.3	1.0	13	17
Median	9.64	0.157	0.045	0.11	26.3	3.3	20	8
Average	9.67	0.25	0.056	0.20	32.9	6.2	27	5
M QZ-QE-POR-QTP-MIN	9.71	0.38	0.100	0.28	22.7	8.8	14	2.6
7. QZ - Qtz-eye Porphyry + QTP (QZ-QE-POR-QTP), 11 samples								
25th, %ile	9.45	0.161	0.010	0.14	16.2	4.2	24	4
Median	9.59	0.310	0.010	0.30	18.3	9.4	33	**2.0**
Average	9.57	0.33	0.028	0.30	30.8	9.6	35	3.2
8. Low-Grade Ore, 8 samples								
25th, %ile	9.35	0.433	0.009	0.36	17.4	11.1	4	**1.6**
Median	9.48	0.506	0.050	0.42	24.1	13.2	27	**1.8**
Average	9.50	0.55	0.066	0.49	26.2	15.3	21	**1.7**
M LGO	9.48	0.28	0.090	0.19	49.2	5.9	43	8
MLGO-Met	9.16	0.59	< 0.02	0.60	28.9	18.8	10	1.5

Notes:

S_{TOTAL} - Total Sulphur; $S_{SULPHATE}$ - Sulphate Sulphur; AP - Acid Potential; AP=$S_{SULPHIDE}$(%) x 31.25.

NNP - Net Neutralization Potential; NPR - Neutralization Potential Ratio;

TIC - Total Inorganic Carbon; Overburden AP is calculated using S_{TOTAL} x 31.25.

Respective samples from Phase I and II are combined.

Table IR-21.4 Comparison of trace element statistics for individual samples to composite samples (ID is in bold).

	Ag	Al	As	B	Be	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	P	Pb	Se	Tl	U	V	Zn
ACUCx10	530	407639	48	-	21	0.90	173	920	280	320415	0.5	774.5	11	470	654	170	0.9	9	27	970	670
Units	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
1. Qtz-eye Porphyry and Qtz-Porphyry Breccia (QE-POR and QE-POR-BX), 66 samples																					
25th, %ile	0.006	5785	0.50	-	0.050	0.010	2.7	46.5	2.5	2860	0.025	320	0.53	1.9	19	0.37	0.35	0.010	0.085	7.0	8
Median	0.025	6345	0.60	-	0.070	0.010	4.5	73	4.7	13000	0.025	418	0.90	2.4	25	0.86	0.35	0.01	0.13	17.0	16
Average	0.029	9000	0.87	-	0.25	0.027	7.0	75	11.3	16551	0.025	537	1.4	6.0	28	1.5	0.42	0.10	0.21	38	21
M QE-POR	0.02	11000	< 0.5	-	0.06	< 0.02	6.3	100	14.0	25000	< 0.05	580	2.2	13.0	190	0.9	< 0.7	< 0.02	0.09	31.0	17
2. Aphanitic Qtz Porphyry (AQPOR), 19 samples																					
25th, %ile	0.005	6800	0.38	-	0.045	0.010	3.1	48.0	2.1	17500	0.025	295	1.05	1.55	21	0.22	0.35	0.010	0.093	5.5	15
Median	0.010	8700	0.60	-	0.060	0.010	4.7	82	4.3	23000	0.025	400	1.80	2.2	25	0.60	0.35	0.01	0.12	10.0	22
Average	0.029	11093	0.80	-	0.14	0.023	7.2	76	12.0	22955	0.025	494	1.8	7.7	23	0.93	0.49	0.05	0.15	18	28
M AQPOR	0.05	14000	0.7	-	0.10	< 0.02	8.4	110	15.0	33000	< 0.05	680	3.5	22.0	380	0.7	< 0.7	< 0.02	0.10	28.0	42
3. Conglomerate (CG), 9 samples																					
25th, %ile	0.050	5400	1.2	-	0.18	0.050	10.0	23	9.4	4420	0.025	**881**	0.30	16	56	2.1	0.35	0.010	0.400	30.0	40
Median	0.050	6470	1.6	-	0.23	0.050	11.0	66	22.0	22000	0.025	**918**	0.30	20	61	3.0	0.35	0.02	0.67	36.0	48
Average	0.058	7119	2.0	-	0.49	0.069	14.2	53	30.6	15193	0.025	**962**	0.43	20	59	4.9	0.42	0.12	0.75	69	49
M CG	0.05	6500	1.3	-	0.16	0.070	11.0	53	30.0	24000	< 0.05	1100	1.1	18.0	400	2.3	< 0.7	0.03	0.50	27.0	46
5. Mafic Dike (MD), 19 samples																					
25th, %ile	0.020	7540	0.50	-	0.060	0.030	18.7	30	11.3	7305	0.025	**1300**	0.20	4.5	22	0.49	0.35	0.010	0.032	146.0	52
Median	0.040	27000	0.80	-	0.090	0.050	32.0	56	55.1	65000	0.025	**1650**	0.30	7.1	25	0.84	0.35	0.01	0.06	250.0	81
Average	0.036	22793	1.2	-	0.26	0.040	27.4	109	67.3	47647	0.025	**1507**	0.44	26	28	1.9	0.41	0.11	0.15	223	67
M MD	0.03	35000	1.4	-	0.18	0.040	36.0	120	69.0	84000	< 0.05	1800	0.9	38.0	200	0.7	< 0.7	< 0.02	0.10	280.0	90
6. QZ - Qtz-eye Porphyry + Minor QTP (QZ-QE-POR-QTP-MIN), 10 samples																					
25th, %ile	0.005	4425	0.25	-	0.040	0.010	1.3	3.2	2.9	10050	0.025	248	1.03	0.60	-	0.27	0.35	0.010	0.072	3.5	6
Median	0.010	5200	0.38	-	0.045	0.010	2.1	93	4.7	17500	0.025	270	1.4	2.5	-	0.39	0.35	0.01	0.11	7.0	8
Average	0.015	5520	0.45	-	0.053	0.010	2.7	67	4.6	15480	0.025	322	1.6	1.8	-	0.63	0.35	0.01	0.11	8	8
M QZ-QE-POR-QTP-MIN	0.02	8100	0.5	-	0.07	< 0.02	3.5	95	13.0	20000	< 0.05	310	5.4	4.1	120	0.3	< 0.7	< 0.02	0.11	12.0	12
8. Low-Grade Ore, 8 samples																					
25th, %ile	0.028	5360	0.50	-	0.058	0.010	2.1	74	8.1	1503	0.025	245	1.33	1.7	4.5	0.81	0.35	0.010	0.100	3.5	7
Median	0.050	6020	0.50	-	0.11	0.040	3.5	89	11.3	14500	0.025	455	2.1	2.4	5.0	1.4	0.35	0.01	0.14	5.5	14
Average	0.121	6533	1.1	-	0.24	0.15	3.1	83	26.6	11976	0.025	401	3.7	2.5	7.7	2.6	0.41	0.10	0.22	5	12
M LGO	0.02	15000	3.0	-	0.09	0.030	9.9	98	11.0	33000	< 0.05	900	15.0	11.0	190	1.9	< 0.7	< 0.02	0.13	70.0	42
MLGO-Met	0.23	6800	2.6	-	0.08	0.100	4.0	57	19.0	21000	< 0.05	430	2.1	5.0	-	5.3	< 0.7	< 0.02	0.52	10.0	21

Notes:

Respective samples from Phase I and II are combined.

ACUC - Average Concentration in the Upper Crust of the Earth based on Rudnick and Gao (2004); Values exceeding 10x the Average Concentration in the Upper Crust are double underlined and bold.

For the values less than Reportable Detection Limit (RDLs) values, 1/2 of RDLs are used to calculate statistical parameters.

Values in cells highlighted yellow exceed either median or average value for the material. Values in cells highlighted green are between the 25th percentile and average value for the material.

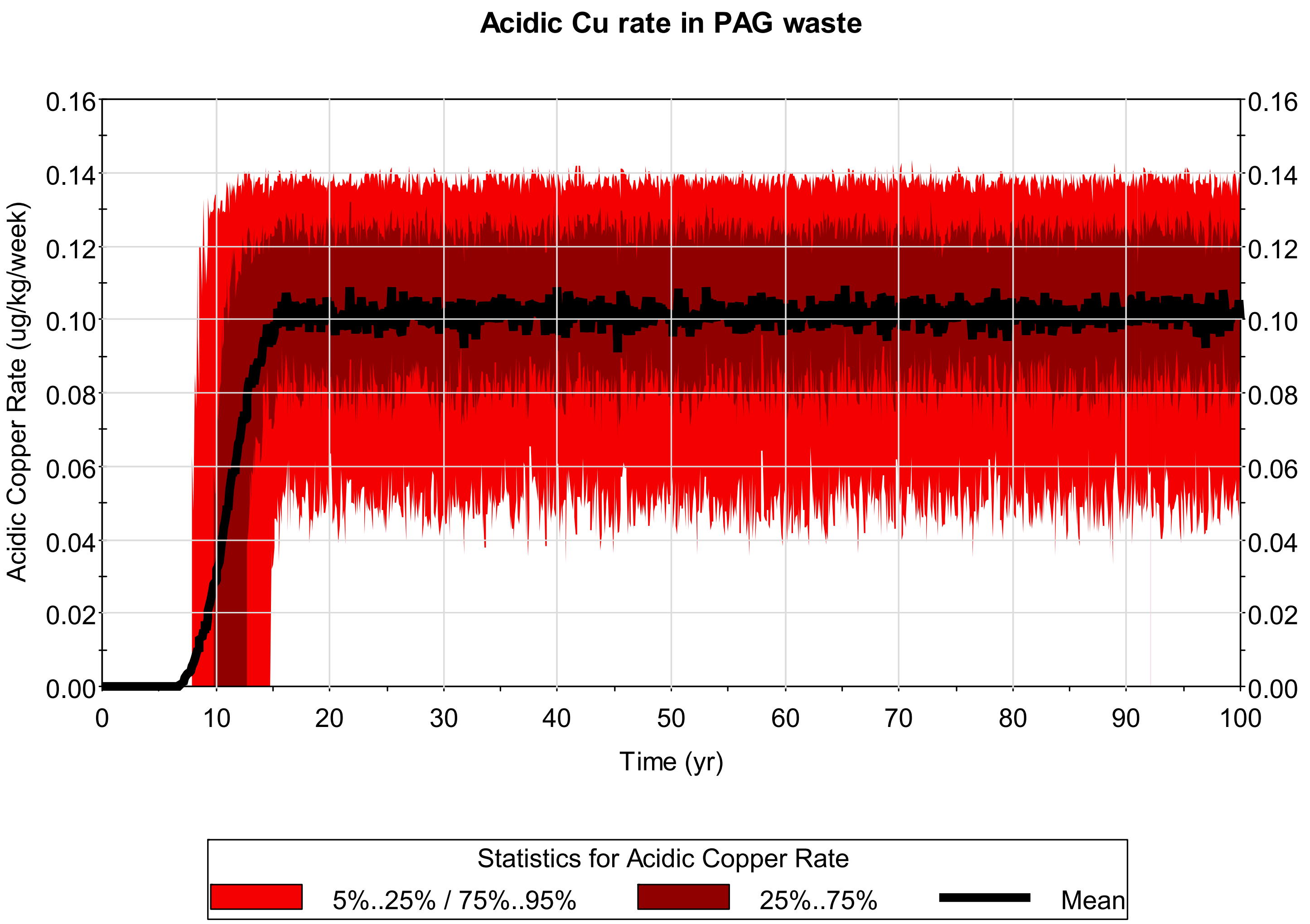

Figure IR-21.1 Probability of acidic Cu rate applied to mass of PAG waste rock

RESPONSE TO IR-22

ID:	**IR-22**
Expert Department or Group:	NRCan-17 MW-45
Guideline Reference:	Section 7.2.2
EIS Reference:	Baseline Study Appendix 5 Attachment 5-A and 5- B
Context and Rationale:	The EIS Guidelines require the proponent to evaluate the effects of imperfect segregation of waste rock. The proponent proposes the development of an ARD block model to identify the location of discrete acid generating pockets of waste rock material and the sequence in which it will be mined. The objective of this is to support the management of potentially acid generating (PAG) waste rock through blending or encapsulation. The success of this approach is dependent in part on the effectiveness of locating and segregating this material. A detailed summary of the ARD block model evaluation was not provided, including an approach to PAG rock segregation.
Information Request:	a. Provide a detailed approach to locate and segregate waste rock for the management of acid generating rock. This can be in the form of an ARD/ML Management Plan. b. Provide a detailed summary of the ARD block model evaluation. c. Provide images presenting the distribution of acid generating waste rock.
Response:	a. The future Acid Rock Drainage (ARD) block model for Marathon pit will provide production schedules for ARD classes of rock and ore and will to help to map potentially acid generating (PAG) materials on pit walls. The model will be verified by operational sampling and managed using the following procedures, which are subject to further refinement as the Acid Rock Drainage/Metal Leaching (ARD/ML) Management Plan is developed: • Samples of drill cuttings from blast holes representing each mine block will be collected. • The samples will be tested for total carbon and sulphur using LECO furnace or similar method. Average neutralization potential (NP) will be calculated from total carbon and average Acid Potential (AP) will be calculated from total sulphur using standard conversions per the Mine Environment Neutral Drainage (MEND) guidelines. If NP/AP ratios indicate the mine block rock is below 2, the block will be classified as PAG.

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	- PAG rock will be marked after the blast, excavated, and dispatched to the waste rock stockpile. PAG rock would only be deposited within a specified distance (to be defined) of the final stockpile shell and preferably next to a non-PAG truck load. Piled PAG rock will be marked and the geospatial coordinates recorded. - A portion of PAG and non-PAG rock loads will be mixed during grading each lift of the stockpile. - This mixture will be encapsulated with non-PAG rock deposited within a specified distance (to be defined) from the lift face and forming the topmost lift(s) on the final of the stockpile. Non-PAG rock will reduce oxygen flux into interior of the pile and provide alkalinity to infiltrating water. This approach has been successfully applied for waste rock piles in other mine sites as referenced in Sections 6.6.3.5 and 6.6.3.6 of Global ARD management guide (http://www.gardguide.com/index.php/Chapter) and would be applicable to ARD/ML management at the Valentine Gold Project. Additional details describing the location and management of acid generating rock will be presented in the ARD/ML Management Plan, however, the approach is expected to be much the same as described above. The ARD/ML Management Plan will be prepared using additional ARD/ML test results as described in Appendix IR-19.A. b./c. The ARD block model for Marathon pit has not yet been developed and will be completed as part of additional ARD/ML work described in Appendix IR-19.A. A summary of the ARD block model evaluation and images presenting the distribution of acid generating waste rock in the pit will be provided to regulators, including NRCan, for review and comment through the proposed ARD/ML Management Plan.
Appendix:	None

RESPONSE TO IR-23

ID:	**IR-23**
Expert Department or Group:	NRCan-18
Guideline Reference:	Section 7.2.2
EIS Reference:	Baseline Study Appendix 5 Attachment 5-A and 5- B Section 2.0 Project Description Chapter 7 Appendix 7A and 7B
Context and Rationale:	The EIS Guidelines require the proponent to evaluate the pit water chemistry during operation and post-closure, and pit closure management measures (e.g., flooding). This will include geochemical modelling of pit water quality in the post-closure period. In the geochemical baseline study, four samples were collected and tested from the gabbro unit at the Marathon Pit, suggesting it is a nominal unit in terms of overall tonnage. However, it appears to constitute a portion of the exposed pit wall based on cross-sections provided in Appendix A, and Figure 2.7-a of the Project Description, and is considered to represent 12% of the pit rubble and walls in the water quality model. This sample count is not considered sufficient to capture the potential variability of this unit with respect to ARD/ML, particularly considering that one of the four samples was classified as potentially acid generating (PAG). Additionally, a composite sample was not generated and tested for this unit, so the long-term ARD/ML potential is not known. NRCan considers this to be a significant data gap with respect to evaluating the quality of pit water discharge during operations and long-term pit lake water quality. Further, the low grade ore and ore at the Marathon Pit are assigned 5% of the area of the pit rubble and walls in the water quality model. Based on the same cross sections, this value appears to underrepresent the likely exposed surface area of these units. In total, 50% and 67% of samples of low grade ore and ore, respectively, have been classified as PAG. PAG samples of low grade ore and ore were not subjected to kinetic testing, and as such the long-term ARD/ML potential of these units is not known, nor their potential impacts to pit water quality during operations and long-term closure. The potential for Marathon Pit water to be acidic with an elevated metal load has not been sufficiently evaluated for operations, closure, and post-closure phases of the Project.
Information Request:	a. Provide a detailed plan to address the data gap in the program on how to allow for the conservative evaluation of the ARD/ML potential of the gabbro waste rock unit, low grade ore, and ore, including plans for additional sample collection, static and kinetic tests.

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	b. Provide proportions of exposed gabbro, low grade ore, and ore for each year of operation, and the final pit shell. c. Complete an evaluation of the pit water chemistry during operations, pit filling, and post-closure, and the potential for the development of acidic drainage. This must include timing to onset of ARD and acidic loading rates from new humidity cell tests on PAG material from the gabbro, low grade ore, and ore as well as the exposed pit shell proportions during the life of the mine.
Response:	a. Marathon recognizes that further Acid Rock Drainage/Metal Leaching (ARD/ML) work is required and further assessment and associated refinement of Project mitigation as design of the Project proceeds (refer to Appendix IR-19.A for further information). Specifically, Marathon is committed to completing additional work to address testing gaps identified in the program completed to date, and as noted by NRCan, within the next 6 to 8 months and prior to construction. This information is required for final design and permitting under the NL *Mines Act* (NL Department of Industry, Energy, and Technology), and will be shared with NRCan as it becomes available: 1. Continuation of laboratory tests include two humidity cells containing carbonate depleted low-grade ore (LGO) and tailings from the Marathon deposit. Continuation of field bin tests of composite materials include nine composite samples representing major waste rock lithologies and low-grade ores from both deposits. In 2021, a subaqueous column, an aging test and a humidity cell has started on samples generated from on-going metallurgical work. Additional kinetic testing of PAG materials (waste rock, ore and low-grade ore) from major lithologies of the Marathon pit including a composite sample of gabbro. These samples will also be submitted for static tests including net acid generating (NAG) tests, mineralogy and particle size distribution similar to characterization of composite samples described in the EIS. 2. Additional static testing: • To address spatial distribution and sampling requirements per lithology (refer to Tables IR-18.2 and IR-18.3) • To provide the data inputs required for ARD block models for Marathon pit • To better define the location and volumes of non-potentially acid generating (non-PAG) rock, which is required for construction, in Leprechaun and Marathon starter pits

ID:	**IR-23**
	b. Proportions of non-exposed PAG and PAG materials on pit walls including gabbro, low-grade ore, and ore are provided in Table IR-23.1. c. Predicted pit water chemistry presented in the EIS is considered to be conservative based on the discussion and additional sensitivity analysis provided in response to IR-21d and e. Pit water chemistry will be revaluated if additional kinetic testing of gabbro, ore and low-grade ore indicate that leaching rates for parameters of concern are higher than and/or ARD onset time is shorter than currently applied as model inputs.
Appendix:	None

Table IR-23.1 Marathon - Pit Shell Lithology Exposure - B632 (Post PFS)

Marathon										
Cumulative Pit Wall Exposure (m^2)										
Year	**-1**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Gabbro Waste	0	0	15,600	83,400	85,700	93,500	98,600	98,800	98,800	98,800
Low Grade Ore	28,700	31,700	34,300	37,600	31,800	32,400	31,500	32,400	34,000	29,700
High Grade Ore	4,300	15,200	16,000	26,100	27,800	27,600	27,100	23,800	21,700	18,000
Total Pit Walls	298,800	490,300	579,000	877,000	927,000	966,100	983,700	1,029,700	1,067,900	1,105,900
Leprechaun										
Cumulative Pit Wall Exposure (m^2)										
Year	-1	1	2	3	4	5	6	7	8	9
Low Grade Ore	13,900	18,900	19,300	23,200	22,300	22,700	29,100	22,000	24,800	24,700
High Grade Ore	11,200	18,100	25,300	28,700	24,200	32,800	35,300	35,400	32,900	30,500
Total Pit Walls	224,400	280,700	470,500	662,000	700,200	749,000	789,500	821,500	841,000	854,100

Reference:

Gabbro Lithology Solids from JTBoyd, January 2020 (VLMA_GAB.dxf)

Pit Shells and End of Period timing from 2020 PFS Engineering (M613 SURF CLP.msr, L623 SURF CLIP.msr, and mine schedule scd10b)

Mineralized Ore measued by any block with definition above 0.33 g/t (Au in model from JT Boyd, 'VLMA_January_2020_Hybrid_Diluted.csv', 'VLLP_January_2020_Dil.csv'). Low grade ore dfined with grades between 0.33 and 0.80 g/t.

Areas in m^2, measured on the surface orientation

RESPONSE TO IR-24

ID:	**IR-24**
Expert Department or Group:	NRCan-19 MFN-16
Guideline Reference:	Section 7.2.2
EIS Reference:	Baseline Study Appendix 5 Attachment 5-A and 5- Band Project Description and Chapter 7 Appendix 7A and 7B
Context and Rationale:	The EIS Guidelines require the proponent to evaluate the longer term rates of acid generation and metal leaching, and estimates of the potential time to onset of acid rock drainage or metal leaching. Of the low grade ore, approximately 10% from the Leprechaun Pit and 50% from the Marathon Pit have been classified as potentially acid generating. Per NRCan-16, all tested composite samples, including low grade ore, are non-potentially acid generating. As such, the long-term ARD potential of problematic low grade ore and ore cannot be evaluated, nor the associated metal load. The Proponent has assumed that the Low Grade Ore stockpile will not be acidic during the tie in which it is stockpiled. This is not a reasonably conservative assumption for the sake of assessing potential for ARD/ML (and downstream impacts to fish and fish habitat/water quality) Low grade ore will be stockpiled adjacent to both pits for blending with higher grade ore or processing towards the end of mine life. At the Marathon Pit, the lag time to generation of ARD is considered to be within the expected residency time of material in the low grade ore stockpile. The timing to onset of acidic conditions was determined based on non-acid generating kinetic tests per NRCan-16 and NRCan does not consider this a reasonably conservative estimate of timing to ARD/ML production in the low grade ore stockpile. Further, the reactivity of the material in the stockpile depends in part on the sequence in which material is mined.
Information Request:	a. Provide an evaluation of the sequencing of low grade ore from the Marathon Pit and the ARD/ML potential of material during the life of the mine. b. Evaluate the sensitivity of the water quality model predictions to the sequencing of low grade ore in the stockpile at the Marathon Pit during the life of the mine. c. Provide mitigation options for the management and treatment of ARD/ML generated from the low grade ore stockpiles. Describe the preventative measures that would be taken to reduce ARD/ML from the low grade ore stockpile, the monitoring plan and if the stockpile and

ID:	IR-24
	effluent will be hydrologically segregated to ensure the effluent can be monitored and treated prior to ARD/ML onset.
Response:	a. The sequencing of potentially acid generating (PAG) and non-PAG low grade ore from the Marathon pit will be provided in the Acid Rock Drainage/Metal Leaching (ARD/ML) Management Plan, which will be developed and submitted during the permitting stage of the Project (refer to Appendix IR-19.A for further information). ARD potential will be identified and managed during the mine life as discussed in part c) of the response to this IR (IR-24). b. The sensitivity of the water quality model to the variability and sequencing of PAG and non-PAG low grade ore from the Marathon pit in the stockpile was assessed by assigning a triangular probability distribution function to the percentage of PAG ore in the stockpile with the following parameters: minimum 0% of PAG, most likely 50% of PAG and maximum 100% of PAG. The results of sensitivity runs are provided in Tables IR-24.1 to IR-24.3 including: 1) original results from the EIS model; 2) new results from the sensitivity model, and 3) ratios of new results to the original results, respectively. The results indicate that 95% probability concentrations may increase up to 4.8x for Ni, up to 1.9x for Fe, up to 1.6x for Cd, and up to 1.4x for Pb compared to the original results. These concentrations are below *Metal and Diamond Mining Effluent Regulations* (MDMER) limits. Therefore, treatment of discharge from low grade ore is not warranted, which is consistent with the conclusion presented in the EIS. c. All PAG materials including low grade ore will be identified and tracked as discussed in the response to IR-22, part a). To limit exposure of PAG low grade ore in the Marathon low-grade ore (LGO) stockpile, this material will be preferentially directed to the mill feed, while non-PAG ores will be allocated to the stockpiles, as long as the grade requirement for the mill feed is met. The preliminary target is to maintain over 15% of non-PAG ore on annual basis to produce enough alkalinity for neutralization of PAG ore as discussed in Appendix IR-21.B. This target will be reviewed and updated (as required) as ARD/ML testing and mine planning proceed. Seepage from the LGO stockpiles will be monitored separately from the final discharge points identified in the EIS. If the seepage water quality approaches MDMER limits, water management of LGO stockpile seepage will be adapted and additional mitigation(s) will be introduced to maintain water quality at the stockpile, likely in the form of specific water treatment. The plan is that all low grade ore will be milled,

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	however, if factors arise whereby the ore is not milled, any remaining low grade ore will be relocated to the open pit and flooded to avoid the need for water treatment after mine closure. Additional details related to water management of drainage from the low grade ore are discussed in Section 7.4.1.1 of the EIS.
Appendix:	None

Table IR-24.1: The highest value of the monthly mean and 95th %-ile for each project phase in seepage from the low grade ore stockpile in the EIS model

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	16	22	86	100	**600**	**600**
Antimony	µg/L	-	-	-	0.5	0.5	0.97	1.10	20	25
Arsenic	µg/L	100	-	5	0.5	0.5	0.8	0.9	**13**	**15**
Barium	µg/L	-	-	-	2.3	3	3.7	4.1	62	73
Boron	µg/L	-	29000	1500	25	25	30	31	220	270
Cadmium	µg/L	-	0.13	0.04	0.01	0.01	0.009	0.011	**0.18**	**0.21**
Calcium	µg/L	-	-	-	2800	2900	6300	7200	150000	180000
Chromium	µg/L	-	-	1	1.1	1.9	**1.2**	**1.8**	**3.3**	**4.0**
Copper	µg/L	100	-	2	0.6	0.9	0.86	0.97	**13**	**15**
Iron	µg/L	-	-	300	25	25	28	29	180	270
Lead	µg/L	80	-	1	0.25	0.25	0.27	0.27	0.92	**1.10**
Magnesium	µg/L	-	-	-	340	350	720	800	16000	19000
Manganese	µg/L	-	596	210	5.5	6.8	19	23	**610**	**740**
Mercury	µg/L	-	-	0.026	0.007	0.007	0.010	0.010	**0.15**	**0.19**
Molybdenum	µg/L	-	-	73	1.0	1.0	3.7	4.5	**110**	**140**
Nickel	µg/L	250	-	25	1.0	1.0	1.2	1.2	7.9	10
Phosphorus	µg/L	-	-	4	50	50	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	95	130	570	700	20000	24000
Selenium	µg/L	-	-	1	0.25	0.25	0.39	0.44	**6.1**	**7.4**
Silver	µg/L	-	-	0.25	0.05	0.05	0.066	0.070	**0.69**	**0.83**
Sodium	µg/L	-	-	-	1400	1500	3600	4300	91000	110000
Thallium	µg/L	-	-	0.8	0.05	0.05	0.056	0.059	0.31	0.40
Uranium	µg/L	-	33	15	0.05	0.05	0.86	1.20	**31**	**42**
Zinc	µg/L	400	11.3	2.2	2.5	2.5	**3.1**	**3.3**	**88**	**250**
Chloride	µg/L	-	640000	120000	2400	2600	2400	2600	2400	2600
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	38	53	4800	12000	12000	15000
Nitrite (as Nitrogen)	µg/L	-	-	60	9.9	14	**120**	**280**	**270**	**350**
Nitrate (as Nitrogen)	µg/L	-	550000	13000	25	25	4600	12000	11000	**15000**
Total Ammonia (as Nitrogen)	µg/L	-	-	689	25	25	610	**1500**	**1500**	**1900**
Un-ionized Ammonia (as Nitrogen)	µg/L	500	-	19	0.064	0.097	**23.0**	**57**	**57**	**72**
Cyanide, Total	µg/L	500	-	-	10	10	10	10	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	1000	1000	5400	6800	180000	220000
Fluoride	µg/L	-	-	120	60	60	85	93	**1100**	**1300**
Radium-226	Bq/L	0.37	-	-	0.005	0.005	0.0067	0.0071	0.074	0.088
Temperature	°C	-	-	-	12.0	17.0	9	17	9	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	8.8	9.7	12000	15000	510000	610000
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.0	6.9	8.0	8.0	8.0	8.0
Hardness (as $CaCO_3$)	mg/L	-	-	-	8.4	8.7	19	21	440	530
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.3	1.4	15	18

Notes:

MDMER - Metal and Diamond Mining Effluent Regulations (Canada), Table 1 of Schedule 4, Maximum Authorized Monthly Mean Concentrations (SOR/2002-222 2020).

CWQG - Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life, short-term and long-term (CWQG-FAL referred to as CWQG) by Canadian Council of Ministers of the Environment (CCME 2020).

Concentrations exceeding MDMER are highlighted gray, CWQG short-term are double underlined, and CWQG long-term are bold.

For further details on the parameters and guidelines see Table C-1 notes in Appendix 7B of the EIS.

Table IR-24.2: The highest value of the monthly mean and 95th %-ile for each project phase in seepage from the low grade ore stockpile in the sensitivity model

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	16	22	86	100	**600**	**600**
Antimony	µg/L	-	-	-	0.5	0.5	0.97	1.10	20	25
Arsenic	µg/L	100	-	5	0.5	0.5	0.8	0.9	**13**	**15**
Barium	µg/L	-	-	-	2.3	3	3.7	4.1	62	73
Boron	µg/L	-	29000	1500	25	25	30	31	220	270
Cadmium	µg/L	-	0.13	0.04	0.01	0.01	0.009	0.011	**0.26**	**0.33**
Calcium	µg/L	-	-	-	2800	2900	6300	7200	150000	180000
Chromium	µg/L	-	-	1	1.1	1.9	**1.2**	**1.8**	**3.3**	**4.0**
Copper	µg/L	100	-	2	0.6	0.9	0.86	0.97	**14**	**17**
Iron	µg/L	-	-	300	25	25	28	29	**340**	**500**
Lead	µg/L	80	-	1	0.25	0.25	0.27	0.27	**1.10**	**1.50**
Magnesium	µg/L	-	-	-	340	350	720	800	16000	19000
Manganese	µg/L	-	596	210	5.5	6.8	19	23	**610**	**740**
Mercury	µg/L	-	-	0.026	0.007	0.007	0.010	0.010	**0.15**	**0.19**
Molybdenum	µg/L	-	-	73	1.0	1.0	3.7	4.5	**110**	**140**
Nickel	µg/L	250	-	25	1.0	1.0	1.2	1.2	**29.0**	**48**
Phosphorus	µg/L	-	-	4	50	50	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	95	130	570	700	20000	24000
Selenium	µg/L	-	-	1	0.25	0.25	0.39	0.44	**6.1**	**7.4**
Silver	µg/L	-	-	0.25	0.05	0.05	0.066	0.070	**0.69**	**0.83**
Sodium	µg/L	-	-	-	1400	1500	3600	4300	91000	110000
Thallium	µg/L	-	-	0.8	0.05	0.05	0.056	0.059	0.31	0.40
Uranium	µg/L	-	33	15	0.05	0.05	0.86	1.20	**31**	**42**
Zinc	µg/L	400	11.3	2.2	2.5	2.5	**3.1**	**3.3**	**180**	**280**
Chloride	µg/L	-	640000	120000	2400	2600	2400	2600	2400	2600
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	38	53	4800	12000	12000	15000
Nitrite (as Nitrogen)	µg/L	-	-	60	9.9	14	**120**	**280**	**270**	**350**
Nitrate (as Nitrogen)	µg/L	-	550000	13000	25	25	4600	12000	11000	**15000**
Total Ammonia (as Nitrogen)	µg/L	-	-	689	25	25	610	**1500**	**1500**	**1900**
Un-ionized Ammonia (as Nitrogen)	µg/L	500	-	19	0.064	0.097	**23.0**	**57**	**57**	**72**
Cyanide, Total	µg/L	500	-	-	10	10	10	10	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	1000	1000	5400	6800	200000	240000
Fluoride	µg/L	-	-	120	60	60	85	93	**1100**	**1300**
Radium-226	Bq/L	0.37	-	-	0.005	0.005	0.0067	0.0071	0.074	0.088
Temperature	°C	-	-	-	12.0	17.0	9	17	9	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	8.8	9.7	12000	15000	510000	610000
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.0	6.9	8.0	8.1	8.0	8.1
Hardness (as $CaCO_3$)	mg/L	-	-	-	8.4	8.7	19	21	440	530
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.3	1.4	15	18

Notes:

MDMER - Metal and Diamond Mining Effluent Regulations (Canada), Table 1 of Schedule 4, Maximum Authorized Monthly Mean Concentrations (SOR/2002-222 2020).

CWQG - Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life, short-term and long-term (CWQG-FAL referred to as CWQG) by Canadian Council of Ministers of the Environment (CCME 2020).

Concentrations exceeding MDMER are highlighted gray, CWQG short-term are double underlined, and CWQG long-term are bold.

For further details on the parameters and guidelines see Table C-1 notes in Appendix 7B of the EIS.

Table IR-24.3: Concentration ratios between the sensitivity and EIS models for the low grade ore stockpile

Parameter	Construction		Operation	
Statistics	mean	95 %ile	mean	95 %ile
Aluminum	1.0	1.0	1.0	1.0
Antimony	1.0	1.0	1.0	1.0
Arsenic	1.0	1.0	1.0	1.0
Barium	1.0	1.0	1.0	1.0
Boron	1.0	1.0	1.0	1.0
Cadmium	1.0	1.0	**1.4**	**1.6**
Calcium	1.0	1.0	1.0	1.0
Chromium	1.0	1.0	1.0	1.0
Copper	1.0	1.0	1.1	1.1
Iron	1.0	1.0	**1.9**	**1.9**
Lead	1.0	1.0	1.2	**1.4**
Magnesium	1.0	1.0	1.0	1.0
Manganese	1.0	1.0	1.0	1.0
Mercury	1.0	1.0	1.0	1.0
Molybdenum	1.0	1.0	1.0	1.0
Nickel	1.0	1.0	**3.7**	**4.8**
Phosphorus	1.0	1.0	1.0	1.0
Potassium	1.0	1.0	1.0	1.0
Selenium	1.0	1.0	1.0	1.0
Silver	1.0	1.0	1.0	1.0
Sodium	1.0	1.0	1.0	1.0
Thallium	1.0	1.0	1.0	1.0
Uranium	1.0	1.0	1.0	1.0
Zinc	1.0	1.0	**2.0**	1.1
Chloride	1.0	1.0	1.0	1.0
Nitrate + Nitrite (as Nitrogen)	1.0	1.0	1.0	1.0
Nitrite (as Nitrogen)	1.0	1.0	1.0	1.0
Nitrate (as Nitrogen)	1.0	1.0	1.0	1.0
Total Ammonia (as Nitrogen)	1.0	1.0	1.0	1.0
Un-ionized Ammonia (as Nitrogen)	1.0	1.0	1.0	1.0
Cyanide, Total	1.0	1.0	1.0	1.0
Cyanide, WAD	1.0	1.0	1.0	1.0
Sulphate	1.0	1.0	1.1	1.1
Fluoride	1.0	1.0	1.0	1.0
Radium-226	1.0	1.0	1.0	1.0
Temperature	1.0	1.0	1.0	1.0
Total Alkalinity (as $CaCO_3$)	1.0	1.0	1.0	1.0
pH (mean or 5 %ile)	1.0	1.0	1.0	1.0
Hardness (as $CaCO_3$)	1.0	1.0	1.0	1.0
Dissolved Organic Carbon	1.0	1.0	1.0	1.0

Note: Ratios above 1.2 are bold and highlighted gray.

RESPONSE TO IR-25

ID:	**IR-25**
Expert Department or Group:	NRCan-20
Guideline Reference:	Section 7.2.2
EIS Reference:	Baseline Study Appendix 5 Attachment 5-A and 5- Band Chapter 7 Appendix 7A and 7B
Context and Rationale:	Section 7.2.2 of the EIS Guidelines require the proponent to complete a geochemical characterization of tailings in order to predict metal leaching and acid rock drainage (ARD/ML). Insufficient information was provided on the origin of the tailings samples analyzed to understand whether they are representative of the anticipated thickened tailings composition to be managed on the property. Previous testing of tailings demonstrate that it could be potentially acid generating. Any deviation from the head ore composition or methods used to generate these samples could result in a different ARD potential and concentrations of cyanide species and associated nitrogen by-products from cyanide degradation, which has implications for tailings runoff, seepage quality and water treatment design.
Information Request:	a. Provide additional information on the source of the contaminated neutral drainage tailings samples, including the head ore composition used to generate these samples relative to the anticipated average ore feed to the plant, and the metallurgical process and cyanide destruction method used to generate these samples relative to the anticipated process to be used during mine operations. b. Complete an analysis of the sensitivity of the water quality model to the generation of ARD/ML from the low grade ore stockpiles.
Response:	a. Figure IR-25.1 shows the average annual grade of ore feed for the plant. Tailings samples CND1 and CND2 were generated from head samples having the composition shown in Table IR-25.1. Tables IR-25.2 and IR-25.3 show the composition of additional head samples prepared to address lateral and vertical variability of ore. The sample preparatory work and cyanide destruction work are detailed in Section 3 of the SGS report entitled "GOLD RECOVERY FROM VALENTINE LAKE PROJECT ORES" prepared for Marathon Gold Project 16863-01 – Report 2 of 3 - Milling" and dated April 15, 2020 (excerpt provided in Appendix IR-25.A). This work can be summarized as follows. The feed sample for each CND test was generated by leaching flotation tailings via mixing the tailings with cyanide-bearing flotation concentrate tailings. The CND product slurries from the gravity-

ID:	IR-25
	flotation-leach circuit were evaluated for the extent of cyanide destruction by sulfur dioxide-air - sometimes referred to as the INCO process. The CN destruction target was 1 mg/L of Weak Acid Dissociable (WAD) CN. The plan is to use the same method and targets for cyanide destruction during Project operation. Additional geochemical testing is being conducted on materials from the gravity-leach circuit and the same method for cyanide destruction. Static testing shows that newly generated tailings are non-PAG with NPR values ranging between 4.0 and 5.9. The kinetic testing includes two subaqueous columns, an aging test and a humidity cell and provide additional results on water quality of the TMF pond and seepage. The results will be considered and reported in the ARD/ML Management Plan. b. The sensitivity of the water quality model to the generation of ARD/ML from the low grade ore stockpile is discussed in responses to IR-21, parts c), d), e) and to IR-24, part b).
Appendix:	Appendix IR-25.A

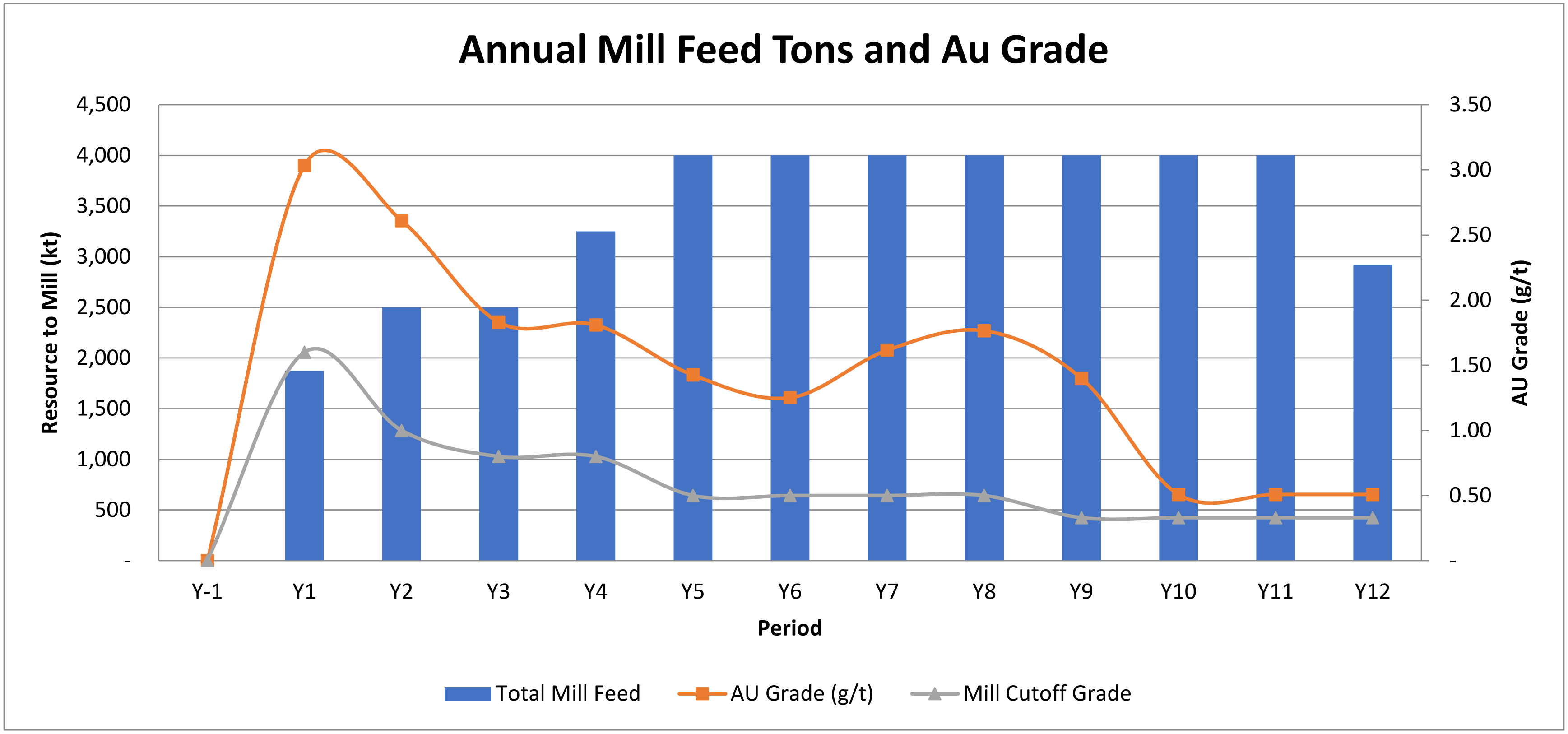


Figure IR-25.1 Annual Mill Feed Tons and Au Grade

IR-25.1 Head Analysis, Quantitative and Semi-quantitative Analysis, Marathon and Leprechaun Zones

Element	LGO Composites						Milling Composites									
	Marathon (MLGO-Met)			Leprechaun (LLGO-Met)			Marathon Comps (tailings CND-1)					Leprechaun Comps (tailings CND-2)				
	A	B	C	D	E	F	MZA	MZB	MZC	MZD	MZE	LZA	LZB	LZC	LZD	LZE
% composite sample	33.3	33.3	33.3	33.3	33.3	33.3	15.7	21.8	21.6	23.6	17.3	27.9	17.3	14.5	20.4	19.9
Quantitative Analyses																
[1] Au, g/t	0.49	0.73	0.90	0.35	0.50	0.76	2.89	4.08	3.25	1.98	3.94	2.69	2.61	5.19	3.82	2.75
Cu, %	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
As, %	<0.001	0.003	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Hg g/t	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
S, %	0.44	0.45	0.66	0.19	0.21	0.31	0.68	0.68	0.79	0.70	0.51	0.30	0.28	0.43	0.34	0.36
$S^=$, %	0.30	0.42	0.59	0.15	0.20	0.30	0.68	0.60	0.74	0.64	0.47	0.28	0.25	0.37	0.34	0.33
C(t), %	0.39	0.41	0.22	0.69	0.75	0.85	0.48	0.41	0.38	0.33	0.38	0.80	0.64	1.40	0.93	0.84
C(g), %	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
TOC Leco, %	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
CO_2, %	1.7	1.8	1.1	2.5	2.7	3.0	1.81	1.52	1.46	1.24	1.49	2.98	2.44	5.12	3.47	3.09
MAP	13.8	14.1	20.6	5.9	6.6	9.7	21.3	21.3	24.7	21.9	15.9	9.4	8.8	13.4	10.6	11.3
NP carb	32.5	34.2	18.3	57.5	62.5	70.8	40.0	34.2	31.7	27.5	31.7	66.7	53.3	116.7	77.1	70.0
Carb NPR	2.4	2.4	0.9	9.7	9.5	7.3	1.9	1.6	1.3	1.3	2.0	7.1	6.1	8.7	7.3	6.2
Spec. Grav	2.71	2.71	2.70	2.72	2.71	2.73	--	--	2.71	--	2.71	--	2.71	--	2.74	--

Table 25-2: Head Assays

Sample ID		Hole	Au	S	SO_4^{2-}	S^{2-}	C	TOC	Cg	Te	NP	AP	NNP	NPR
Method		depth	FAAS	LECO	GRAV	GRAV	LECO	LECO	LECO	ICP				
Units		m	g/t	%	%	%	%	%	%	ppm	kg $CaCO_3$/t			unit less
Zone Comps	MAA	-	1.61	0.69	0.45	0.24	0.49	0.02	<0.01	25	32.9	7.41	25.5	4
	MAB	-	1.86	0.81	0.20	0.61	0.29	0.01	<0.01	22	19.2	19.0	0.2	1.0
	MAC	-	2.18	0.73	0.04	0.70	0.32	<0.01	<0.01	22	21.5	21.8	-0.3	1.0
	MAD	-	1.31	0.57	0.05	0.53	0.29	<0.01	<0.01	32	19.1	16.4	2.7	1.2
	MAE	-	1.99	0.72	0.05	0.67	0.34	<0.01	<0.01	23	22.6	20.8	1.8	1.1
	LPA	-	2.15	0.38	0.02	0.35	0.65	0.03	0.01	24	43.2	11.1	32.1	4
	LPB	-	3.19	0.37	0.01	0.35	0.87	0.02	<0.01	22	57.9	11.1	46.8	5
	LPC	-	1.74	0.49	0.02	0.47	0.87	<0.01	0.01	26	58.1	14.7	43.4	4
	LPD	-	1.69	0.35	0.23	0.12	0.85	<0.01	0.01	25	56.8	3.91	52.9	15
	LPE	-	1.72	0.33	0.02	0.31	1.02	<0.01	0.01	21	68.0	9.71	58.3	7
Master Comps	MAMC	-	4.01	0.74	0.06	0.68	0.33	<0.01	0.01	20	21.8	21.2	0.6	1.0
	LPMC	-	2.18	0.61	0.01	0.60	0.50	0.01	<0.01	21	33.4	18.6	14.8	1.8
Ma Grade Bins	MG1	-	0.55	0.53	0.04	0.49	0.33	0.01	<0.01	19	21.9	15.3	6.6	1.4
	MG2	-	2.10	0.60	0.03	0.57	0.34	<0.01	<0.01	23	22.5	17.8	4.8	1.3
	MG3	-	1.96	0.64	0.28	0.36	0.22	<0.01	<0.01	28	14.5	11.3	3.2	1.3
	MG4	-	2.11	0.47	0.03	0.44	0.28	<0.01	<0.01	25	18.5	13.7	4.8	1.3
	MG5	-	1.87	0.73	0.05	0.68	0.36	<0.01	0.01	20	24.3	21.3	2.9	1.1
	MG6	-	3.63	0.81	0.07	0.74	0.40	<0.01	0.01	38	26.5	23.2	3.3	1.1
Ma Depth Bins	MD1	<50	1.70	0.74	0.04	0.71	0.34	<0.01	<0.01	22	22.3	22.0	0.3	1.0
	MD2	50-120	1.68	0.51	0.08	0.43	0.41	0.01	<0.01	22	27.0	13.6	13.4	2.0
	MD3	120-190	2.17	0.77	0.03	0.73	0.32	0.01	<0.01	20	21.5	22.9	-1.4	0.9
	MD4	190-260	2.45	0.80	0.05	0.75	0.28	0.01	<0.01	24	18.9	23.5	-4.6	0.8
	MD5	>260	2.16	0.32	0.07	0.26	0.83	<0.01	<0.01	25	55.3	8.03	47.3	7
Lp Grade Comps	LG1	-	1.27	0.39	0.01	0.38	0.98	<0.01	<0.01	21	65.3	11.7	53.6	6
	LG2	-	2.02	0.19	0.01	0.18	0.84	<0.01	<0.01	24	55.9	5.57	50.3	10
	LG3	-	3.03	0.25	<.01	0.25	0.75	0.01	<0.01	28	49.9	7.82	42.0	6
	LG4	-	4.85	0.30	0.05	0.25	0.75	<0.01	<0.01	29	49.7	7.90	41.8	6
	LG5	-	3.28	0.24	<.01	0.26	1.06	<0.01	<0.01	29	70.7	8.22	62.5	9
	LG6	-	4.35	0.24	0.01	0.23	0.66	<0.01	<0.01	30	43.7	7.09	36.6	6
Lp Depth Bins	LD1	<50	2.25	0.23	0.01	0.23	0.90	<0.01	<0.01	24	59.8	7.11	52.7	8
	LD2	50-120	1.59	0.24	0.02	0.22	0.76	<0.01	<0.01	31	50.3	6.88	43.5	7
	LD3	120-190	2.57	0.42	0.02	0.40	0.96	<0.01	<0.01	26	63.7	12.4	51.2	5
	LD4	190-260	1.20	0.50	0.05	0.45	1.03	<0.01	0.01	26	68.7	14.0	54.7	5
	LD5	>260	3.06	0.25	0.01	0.23	0.75	<0.01	<0.01	27	50.1	7.31	42.8	7
Ma Comp A		-	1.33	0.87	0.04	0.83	0.29	0.01	0.01	-	19.1	25.9	-6.8	0.7
Ma Comp C		-	1.35	0.94	0.03	0.91	0.39	0.03	0.01	-	25.9	28.3	-2.4	0.9

Table 25-3: Elemental

Analyte Symbol	Hg	Co_3O_4	CuO	NiO	SiO_2	Al_2O_3	$Fe_2O_{3(T)}$	MnO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	Cr_2O_3	V_2O_5	LOI	Total	Al	As	B	Ba	Be	Bi
Unit Symbol	ppb	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	ppm	ppm	ppm	ppm	ppm
Detection Limit	5	0.005	0.005	0.003	0.01	0.01	0.01	0.001	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.003	-	0.01	0.01	5	10	3	3	2
Analysis Method	1G	FUS-XRF	FUS-XRF	FUS-XRF	FUS-XRF	FUS-XRF	FUS-XRF	FUS-XRF	FUS-XRF	FUS-XRF	FUS-XRF	FUS-XRF	FUS-XRF	FUS-XRF	FUS-XRF	FUS-XRF	GRAV	FUS-XRF	FUS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2
MAA Hd	23	< 0.005	< 0.005	< 0.003	73.6	12.24	2.99	0.053	0.87	2.43	4.53	0.49	0.21	0.04	0.02	0.004	2.55	100	6.5	5	630	202	< 3	< 2
MAB Hd	145	< 0.005	0.007	< 0.003	76.3	11.52	2.7	0.039	0.44	1.54	4.3	0.6	0.15	0.03	0.01	< 0.003	1.77	99.41	6.32	21	330	186	< 3	< 2
MAC Hd	9	< 0.005	0.005	< 0.003	74.18	12.47	2.87	0.048	0.53	1.55	5.13	0.56	0.15	0.02	0.01	< 0.003	1.83	99.35	6.63	10	360	172	< 3	< 2
MAD Hd	19	< 0.005	< 0.005	< 0.003	76.03	11.91	2.12	0.043	0.4	1.43	5.19	0.41	0.13	0.02	0.01	0.004	1.54	99.25	6.4	6	430	144	< 3	< 2
MAE Hd	6	< 0.005	< 0.005	< 0.003	74.86	11.84	2.49	0.054	0.55	1.72	4.92	0.44	0.15	0.02	0.01	< 0.003	1.82	98.88	6.32	< 5	410	148	< 3	< 2
LPA Hd	15	< 0.005	< 0.005	< 0.003	69.47	14.9	2.03	0.058	0.81	2.91	5.58	1.26	0.21	0.08	0.01	0.007	2.85	100.2	7.95	< 5	290	1110	< 3	< 2
LPB Hd	10	< 0.005	< 0.005	< 0.003	65.7	14.54	2.75	0.061	1.02	3.44	5.45	1.15	0.36	0.09	0.01	0.009	3.45	98.04	7.94	< 5	400	794	< 3	< 2
LPC Hd	13	< 0.005	< 0.005	< 0.003	65.51	15.32	2.96	0.06	1.07	3.68	6.17	0.9	0.44	0.11	0.01	0.008	3.46	99.7	8.47	< 5	320	622	< 3	< 2
LPD Hd	8	< 0.005	< 0.005	0.003	64.18	15.65	2.73	0.057	1.27	3.95	6.02	0.93	0.32	0.11	0.01	0.008	3.59	98.84	8.46	< 5	530	641	< 3	< 2
LPE Hd	11	< 0.005	< 0.005	0.004	63.64	15.31	3.67	0.079	1.38	4.5	5.09	1.12	0.54	0.12	0.01	0.009	4.23	99.71	8.33	< 5	250	635	< 3	< 2
MAMC Hd	88	< 0.005	< 0.005	< 0.003	74.94	11.85	2.73	0.048	0.53	1.76	4.78	0.52	0.16	0.02	0.02	< 0.003	2.11	99.46	6.35	8	420	168	< 3	< 2
LPMC Hd	7	< 0.005	< 0.005	< 0.003	65.28	15.22	2.8	0.062	1.1	3.7	5.65	1.07	0.35	0.1	0.01	0.007	3.46	98.81	8.21	< 5	370	784	< 3	< 2
MG1 Hd	10	< 0.005	0.006	< 0.003	72.94	11.79	3.35	0.067	0.96	2.42	4.33	0.46	0.22	0.04	0.01	0.007	2.43	99.04	6.31	< 5	440	168	< 3	< 2
MG2 Hd	12	< 0.005	< 0.005	< 0.003	75.06	11.79	2.27	0.046	0.49	1.7	4.82	0.49	0.16	0.02	0.01	< 0.003	1.71	98.57	6.51	< 5	330	183	< 3	< 2
MG3 Hd	7	< 0.005	< 0.005	< 0.003	74.85	11.93	2.75	0.051	0.64	1.77	4.94	0.42	0.16	0.02	0.01	0.003	1.88	99.43	6.46	< 5	400	145	< 3	< 2
MG4 Hd	29	< 0.005	< 0.005	< 0.003	76.25	11.85	2.51	0.036	0.36	1.28	4.79	0.63	0.13	0.02	0.01	< 0.003	1.54	99.42	6.4	7	400	202	< 3	< 2
MG5 Hd	50	< 0.005	< 0.005	< 0.003	76.93	11.19	2.32	0.045	0.47	1.56	4.49	0.48	0.14	0.02	0.01	< 0.003	1.66	99.32	6	21	400	155	< 3	< 2
MG6 Hd	25	< 0.005	< 0.005	< 0.003	71.97	13.26	2.24	0.039	0.44	1.78	5.97	0.42	0.14	0.02	0.01	0.003	1.79	98.06	7.34	7	630	176	< 3	5
MD1 Hd	9	< 0.005	< 0.005	< 0.003	71.07	13.38	3.83	0.06	0.8	2.04	5.57	0.45	0.23	0.04	0.01	0.006	2.2	99.7	7.16	< 5	420	167	< 3	< 2
MD2 Hd	33	< 0.005	< 0.005	< 0.003	75.7	11.68	2.49	0.049	0.46	1.69	4.81	0.5	0.15	0.02	0.02	0.003	1.8	99.39	6.33	< 5	450	166	< 3	< 2
MD3 Hd	28	< 0.005	0.005	< 0.003	74.71	11.67	2.53	0.049	0.72	2.02	4.55	0.47	0.17	0.02	0.01	< 0.003	2.05	98.98	6.26	9	370	138	< 3	< 2
MD4 Hd	9	< 0.005	< 0.005	< 0.003	75.94	11.67	2.37	0.041	0.46	1.68	4.77	0.47	0.16	0.03	0.01	< 0.003	1.74	99.33	6.17	17	430	201	< 3	< 2
MD5 Hd	9	< 0.005	< 0.005	0.008	75.19	11.8	2.77	0.045	0.53	1.65	4.79	0.54	0.15	0.02	0.03	0.004	1.76	99.31	6.44	< 5	380	188	< 3	< 2
LG1 Hd	< 5	< 0.005	< 0.005	< 0.003	63.76	15.15	3.01	0.067	1.13	3.93	5.72	1.01	0.43	0.1	< 0.01	0.01	3.7	98.02	8.22	< 5	320	718	< 3	< 2
LG2 Hd	< 5	< 0.005	< 0.005	< 0.003	63.91	15.68	3.21	0.07	1.17	3.93	5.65	1.13	0.43	0.12	0.01	0.011	3.68	98.99	8.45	< 5	420	676	< 3	< 2
LG3 Hd	< 5	< 0.005	< 0.005	< 0.003	67.29	15	2.47	0.057	0.98	3.26	5.51	1.17	0.28	0.08	0.01	0.007	3.04	99.14	7.97	< 5	320	947	< 3	< 2
LG4 Hd	6	< 0.005	< 0.005	< 0.003	66.84	15.07	2.2	0.054	0.88	3.19	6.02	0.99	0.26	0.08	0.01	0.006	2.88	98.5	8.24	< 5	310	777	< 3	< 2
LG5 Hd	< 5	< 0.005	< 0.005	0.006	63.55	14.67	3.45	0.078	2.45	4.11	4.92	0.95	0.37	0.08	0.02	0.011	4.71	99.37	7.78	< 5	560	675	< 3	< 2
LG6 Hd	< 5	< 0.005	< 0.005	0.007	68.61	14.62	2.11	0.043	0.75	3.13	5.59	1.07	0.25	0.09	0.01	0.005	2.69	98.98	7.91	< 5	330	625	< 3	< 2
LD1 Hd	< 5	< 0.005	< 0.005	< 0.003	65.23	15.47	3.07	0.067	1.36	3.68	5.47	1.11	0.37	0.1	0.01	0.009	3.74	99.7	8.1	< 5	340	798	< 3	< 2
LD2 Hd	< 5	< 0.005	< 0.005	< 0.003	66.12	15.55	2.25	0.054	0.86	3.55	5.62	1.16	0.28	0.1	0.01	0.006	3.14	98.71	8.36	< 5	380	716	< 3	< 2
LD3 Hd	< 5	< 0.005	< 0.005	< 0.003	65.37	14.99	2.84	0.063	1.06	3.9	5.78	1.04	0.41	0.1	< 0.01	0.008	3.63	99.2	8.11	< 5	330	731	< 3	< 2
LD4 Hd	< 5	< 0.005	< 0.005	< 0.003	62.6	15.44	3.39	0.072	1.28	4.13	6.08	0.99	0.51	0.11	0.01	0.011	3.93	98.55	8.15	< 5	300	607	< 3	< 2
LD5 Hd	< 5	< 0.005	< 0.005	0.013	67.94	14.86	2.43	0.05	0.99	3.19	5.69	1.03	0.3	0.08	0.02	0.007	2.97	99.58	7.97	< 5	390	792	< 3	< 2

Table 25-3: Elemental

Analyte Symbol	Ca	Cd	Ce	Co	Cr	Cs	Cu	Dy	Er	Eu	Fe	Ga	Gd	Ge	Ho	Hf	In	K	La	Li	Mg	Mn	Mo
Unit Symbol	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm
Detection Limit	0.01	2	0.8	0.2	30	0.1	2	0.3	0.1	0.1	0.05	0.2	0.1	0.7	0.2	10	0.2	0.1	0.4	3	0.01	3	1
Analysis Method	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2
MAA Hd	1.67	< 2	10.2	5.9	110	0.1	24	5	4.3	0.8	2.17	13.3	4.8	2.4	1.3	< 10	< 0.2	0.5	3.6	19	0.46	460	3
MAB Hd	1.06	< 2	10.9	2.4	110	0.4	55	5.6	4.5	0.5	2.07	12.8	4.6	2	1.5	< 10	0.3	0.6	4.6	14	0.23	350	5
MAC Hd	1.06	< 2	13.4	3.9	100	0.3	39	6.8	5.4	0.8	2.15	11.1	5.6	1.9	1.7	< 10	< 0.2	0.5	4.2	14	0.29	379	< 1
MAD Hd	1.01	< 2	12.7	3.3	110	0.6	42	5.9	4.4	1	1.59	11.8	4	1.8	1.5	< 10	< 0.2	0.4	4.9	16	0.21	330	< 1
MAE Hd	1.19	< 2	12.9	2.4	100	1.9	35	6.6	5.2	0.6	1.9	9.9	4.5	1.8	1.5	< 10	0.3	0.4	5.5	13	0.3	430	3
LPA Hd	2.03	< 2	22.5	3.6	80	0.9	22	0.8	0.4	0.8	1.47	17.2	1.2	1.5	< 0.2	< 10	< 0.2	1.1	11.1	13	0.44	456	< 1
LPB Hd	2.5	< 2	26	6.6	90	0.4	30	1.2	0.7	0.6	2.04	17.9	1.9	1.4	0.3	< 10	< 0.2	1	12.7	12	0.59	488	< 1
LPC Hd	2.67	< 2	30.3	5.3	70	0.8	27	1.1	0.6	0.9	2.22	15.8	2.1	1.5	< 0.2	< 10	< 0.2	0.8	15.3	12	0.61	474	< 1
LPD Hd	2.87	< 2	33.6	5.7	90	0.5	20	0.8	0.4	1	1.97	16.7	2.1	1.3	0.2	< 10	< 0.2	0.8	17.9	17	0.73	476	< 1
LPE Hd	3.19	< 2	33.4	6.5	80	0.7	27	1.5	0.8	0.9	2.59	18.5	1.5	1.4	0.3	< 10	< 0.2	1	15.6	14	0.79	591	2
MAMC Hd	1.11	< 2	13.2	4.6	170	0.3	74	6.1	4.9	0.9	2.32	13.9	4.4	1.7	1.5	< 10	< 0.2	0.5	4.7	17	0.3	435	3
LPMC Hd	2.65	< 2	28.9	7.5	100	0.8	41	0.9	0.7	1.1	2.06	15.6	2	1.4	< 0.2	< 10	< 0.2	0.9	13.6	34	0.63	523	1
MG1 Hd	1.71	< 2	10.7	4.1	110	0.2	87	5.4	3.8	1	2.62	14.6	3.7	2.2	1.2	< 10	< 0.2	0.4	3.7	20	0.53	511	2
MG2 Hd	1.2	< 2	12.3	2.3	110	< 0.1	37	6.3	5.1	0.7	1.83	11.9	5	1.8	1.7	20	0.2	0.5	4.4	9	0.26	372	< 1
MG3 Hd	1.25	< 2	12.9	3.5	140	< 0.1	29	6.2	4.5	0.7	2.28	11.2	4.2	1.8	1.6	< 10	< 0.2	0.4	4.7	9	0.35	424	2
MG4 Hd	0.86	< 2	11.9	2.5	130	< 0.1	33	5.7	5.2	0.6	1.88	10	4.2	1.8	1.2	< 10	< 0.2	0.6	5.2	8	0.19	290	2
MG5 Hd	1.04	< 2	11.5	1.8	210	0.5	30	5.7	4.6	0.6	1.87	11.8	3.8	2	1.4	< 10	< 0.2	0.5	5	7	0.24	378	10
MG6 Hd	1.3	< 2	13.1	2.5	470	0.3	17	7.4	5.7	0.9	1.74	13.2	5.3	1.8	1.7	< 10	< 0.2	0.4	4.9	7	0.23	364	< 1
MD1 Hd	1.41	< 2	12.3	6.2	100	0.4	29	5.5	3.7	0.8	3.07	12.7	5.1	1.8	1.3	< 10	< 0.2	0.4	4.3	7	0.45	501	2
MD2 Hd	1.03	< 2	11.7	3	390	0.4	23	5.7	4.8	0.5	1.89	12.2	4.2	1.4	1.2	< 10	< 0.2	0.4	4.2	6	0.24	346	3
MD3 Hd	1.38	< 2	10.2	3.5	120	0.2	45	5.6	4	0.7	1.92	12.8	3.1	2.2	1.4	< 10	< 0.2	0.4	4.2	9	0.4	413	4
MD4 Hd	1.11	< 2	11.4	3	150	0.1	28	6.4	4.4	0.6	1.9	9.9	4.5	1.8	1.5	< 10	0.3	0.5	4.8	13	0.23	351	3
MD5 Hd	1.06	< 2	13.4	1.9	100	0.3	30	7.1	4.6	0.7	2.12	10.9	4.5	1.7	1.5	< 10	< 0.2	0.5	5.2	8	0.28	379	2
LG1 Hd	2.65	< 2	26.1	7.6	90	0.6	20	1.2	0.7	0.9	2.15	15.8	2.1	1	0.2	< 10	< 0.2	0.9	14.3	7	0.63	511	< 1
LG2 Hd	2.65	< 2	30	7.2	100	0.5	25	1.6	0.6	0.8	2.47	17.7	1.8	1.1	0.3	< 10	< 0.2	1	14.5	9	0.65	555	2
LG3 Hd	2.2	< 2	25.1	6.4	140	0.5	21	0.9	0.3	0.7	1.9	18.1	1.5	1.4	0.2	< 10	< 0.2	1	12.5	8	0.51	465	< 1
LG4 Hd	2.14	< 2	25.4	3.9	110	0.6	18	0.7	0.5	0.7	1.81	15.9	1.8	1	< 0.2	< 10	< 0.2	0.9	13.4	6	0.46	438	1
LG5 Hd	2.82	< 2	23.6	11.4	180	0.9	24	1.3	0.8	0.9	2.45	18.8	1.9	1.7	0.3	< 10	< 0.2	0.8	10.4	9	1.38	576	< 1
LG6 Hd	2.18	< 2	25.9	4.7	110	0.4	19	0.6	0.3	0.8	1.66	14.5	1.6	1.3	< 0.2	< 10	< 0.2	0.9	14.5	6	0.4	385	2
LD1 Hd	2.47	< 2	27.1	7.6	120	0.5	20	1.3	1	0.8	2.35	16.9	1.3	1.2	< 0.2	< 10	< 0.2	0.9	14.8	8	0.76	533	< 1
LD2 Hd	2.48	< 2	28.2	3.6	100	0.5	21	0.9	0.5	1.2	1.76	18.6	1.7	1.1	< 0.2	< 10	< 0.2	1	14.4	6	0.47	464	< 1
LD3 Hd	2.79	< 2	27.1	4.5	100	0.7	24	1.1	0.6	0.9	2.05	15	2.2	1.1	0.3	< 10	< 0.2	0.9	15.6	7	0.6	520	< 1
LD4 Hd	2.87	< 2	26.5	7.5	100	0.6	24	1.6	1	0.9	2.58	16.4	1.8	1.6	0.3	< 10	< 0.2	0.9	14.3	7	0.72	592	2
LD5 Hd	2.22	< 2	23.7	7.2	110	0.8	30	1	0.7	0.7	1.87	15.7	1.4	1.6	< 0.2	< 10	< 0.2	0.9	12	7	0.53	458	1

Table 25-3: Elemental

Analyte Symbol	Nb	Nd	Ni	Pb	Pr	Rb	S	Sb	Se	Si	Sm	Sn	Sr	Ta	Tb	Te	Th	Ti	Tl	Tm	U	V	W
Unit Symbol	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
Detection Limit	2.4	0.4	10	0.8	0.1	0.4	0.01	2	8	0.01	0.1	0.5	3	0.2	0.1	6	0.1	0.01	0.1	0.1	0.1	5	0.7
Analysis Method	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2
MAA Hd	< 2.4	8.1	20	9.2	1.2	10.1	0.68	< 2	< 8	> 30.0	3.8	5.8	99	< 0.2	0.8	25	1	0.12	< 0.1	0.5	0.6	29	5.7
MAB Hd	< 2.4	8.6	20	20.5	1.9	11.8	0.71	2	< 8	> 30.0	2.4	6.6	80	< 0.2	1	22	1.1	0.09	0.1	0.7	0.6	9	9.7
MAC Hd	< 2.4	10.1	20	7.6	1.6	7.7	0.68	< 2	< 8	> 30.0	3.6	5.8	63	0.3	1.1	22	1.4	0.09	< 0.1	0.9	0.7	15	3.9
MAD Hd	< 2.4	9.1	40	9.8	1.9	7.3	0.56	< 2	13	> 30.0	2.3	6.3	71	< 0.2	0.9	32	1.2	0.08	< 0.1	0.7	0.7	13	5.9
MAE Hd	< 2.4	8.6	10	4.7	1.8	7.9	0.69	< 2	< 8	> 30.0	3	5.4	70	< 0.2	0.9	23	1.1	0.09	< 0.1	0.8	0.6	15	13.8
LPA Hd	< 2.4	8.9	10	12.3	2.7	27.5	0.22	2	< 8	> 30.0	1.5	5.1	410	< 0.2	0.1	24	0.7	0.12	0.1	< 0.1	0.3	34	3.9
LPB Hd	< 2.4	11.3	10	7.5	2.6	26.6	0.31	< 2	< 8	> 30.0	1.9	4.8	344	< 0.2	0.2	22	1	0.22	0.1	< 0.1	0.4	52	19.8
LPC Hd	< 2.4	11.8	10	8.6	3.6	20.8	0.36	< 2	< 8	> 30.0	1.4	5.2	438	< 0.2	0.3	26	1	0.25	< 0.1	0.2	0.4	56	13.5
LPD Hd	< 2.4	13.9	30	8.7	3.4	17.8	0.34	< 2	< 8	> 30.0	2.1	5.2	511	< 0.2	0.3	25	1.1	0.19	< 0.1	< 0.1	0.4	49	51.3
LPE Hd	< 2.4	13.5	20	9.4	4.1	22.8	0.27	2	< 8	29.5	2.6	3.6	436	< 0.2	0.3	21	1.8	0.3	0.1	0.1	0.5	71	12.6
MAMC Hd	< 2.4	8.4	30	13.9	1.8	9.6	0.69	3	< 8	> 30.0	1.9	5.8	78	< 0.2	0.9	20	1.1	0.09	< 0.1	0.8	0.5	21	8.6
LPMC Hd	< 2.4	10.6	20	9.6	2.9	25.9	0.29	< 2	< 8	> 30.0	2	4.6	417	< 0.2	0.2	21	1	0.21	0.1	0.1	0.4	46	16.3
MG1 Hd	< 2.4	8.8	30	45.8	1.7	8.9	0.56	< 2	< 8	> 30.0	3.9	4.8	85	< 0.2	1	19	1	0.13	0.2	0.6	0.5	33	5.8
MG2 Hd	< 2.4	8.2	20	19.5	1.9	7.5	0.55	< 2	< 8	> 30.0	2.9	5.9	86	< 0.2	1	23	1.2	0.1	< 0.1	0.7	0.7	17	4.7
MG3 Hd	< 2.4	9.8	20	33.6	1.8	8.7	0.72	< 2	< 8	> 30.0	3.5	5.7	73	< 0.2	1	28	1.3	0.09	< 0.1	0.8	0.7	21	12.4
MG4 Hd	< 2.4	9.5	20	15.5	1.6	13.5	0.78	< 2	14	> 30.0	2.8	6	60	0.3	0.9	25	1.3	0.08	< 0.1	0.8	0.5	13	4.6
MG5 Hd	< 2.4	9.6	10	19.7	1.5	9.8	0.6	3	< 8	> 30.0	3.1	6	64	< 0.2	0.9	20	1.2	0.08	< 0.1	0.6	0.6	16	22.5
MG6 Hd	< 2.4	10.5	30	15.8	2.1	8.8	0.71	< 2	< 8	> 30.0	4.2	6.3	79	0.3	1.2	38	1.4	0.09	< 0.1	0.7	0.6	13	4.2
MD1 Hd	< 2.4	12.4	20	6.1	1.9	7.3	0.74	< 2	< 8	> 30.0	3.8	4	76	0.3	1	22	1.2	0.14	< 0.1	0.7	0.6	35	7.1
MD2 Hd	< 2.4	7.7	20	6.1	1.3	9	0.73	2	< 8	> 30.0	2.9	3	66	0.3	0.9	22	1	0.09	< 0.1	0.8	0.5	20	6.4
MD3 Hd	< 2.4	7.4	10	7.9	1.7	7.6	0.55	< 2	< 8	> 30.0	2.7	3.9	82	0.3	0.8	20	1.1	0.1	< 0.1	0.7	0.5	29	5.7
MD4 Hd	< 2.4	8	20	16.7	1.6	8.7	0.7	< 2	< 8	> 30.0	3.3	30.2	68	0.2	0.9	24	1.1	0.09	< 0.1	0.7	0.5	17	5.6
MD5 Hd	< 2.4	10.3	10	10.9	1.9	8.4	0.76	< 2	14	> 30.0	3.1	2.8	77	< 0.2	1	25	1.3	0.09	< 0.1	0.8	0.7	19	18.7
LG1 Hd	< 2.4	13.4	40	8.8	2.7	25.3	0.31	< 2	< 8	> 30.0	1.6	4.5	420	0.4	0.2	21	0.9	0.25	< 0.1	0.1	0.4	65	61.3
LG2 Hd	< 2.4	13.5	20	9.6	3.4	25.7	0.32	< 2	< 8	> 30.0	2.5	3.1	411	0.2	0.3	24	1.1	0.26	< 0.1	0.1	0.5	64	20.8
LG3 Hd	< 2.4	10.8	180	13.3	3	23.2	0.29	< 2	< 8	> 30.0	1.5	2.5	370	< 0.2	0.2	28	0.7	0.17	0.2	< 0.1	0.4	48	10.2
LG4 Hd	< 2.4	11.1	10	10.8	2.7	20.5	0.27	< 2	< 8	> 30.0	1.8	4.2	389	< 0.2	0.2	29	0.8	0.15	< 0.1	< 0.1	0.4	44	10.5
LG5 Hd	< 2.4	10.8	50	12.5	2.3	23.6	0.21	< 2	< 8	29.6	2.2	3.2	399	0.4	0.2	29	0.7	0.21	0.1	< 0.1	0.3	70	6.5
LG6 Hd	< 2.4	11.5	< 10	11	3.3	23.8	0.21	< 2	< 8	> 30.0	2.3	2.8	394	0.4	0.2	30	0.9	0.15	< 0.1	< 0.1	0.4	40	4.8
LD1 Hd	< 2.4	10.7	20	10.4	2.7	25.5	0.22	< 2	< 8	29.9	1.7	3.1	410	< 0.2	0.2	24	1.1	0.21	< 0.1	< 0.1	0.4	64	7.3
LD2 Hd	< 2.4	12.6	20	9.9	2.7	23.2	0.18	< 2	< 8	> 30.0	1.6	4.6	416	0.3	0.2	31	0.9	0.16	< 0.1	< 0.1	0.4	41	6.1
LD3 Hd	< 2.4	12.1	20	10.3	3.1	22.9	0.34	< 2	< 8	> 30.0	2.4	2.4	431	< 0.2	0.3	26	1.1	0.25	0.1	0.1	0.4	56	47.7
LD4 Hd	< 2.4	13.4	20	7.4	3.1	24.2	0.42	< 2	< 8	29.2	2.7	4.1	391	0.2	0.3	26	1	0.31	0.1	0.2	0.4	70	22.4
LD5 Hd	< 2.4	11.1	10	10.5	2.5	20.9	0.3	< 2	< 8	> 30.0	1.8	4.3	379	< 0.2	0.2	27	0.8	0.17	< 0.1	< 0.1	0.3	45	14.2

Table 25-3: Elemental

Analyte Symbol	Y	Yb	Zn
Unit Symbol	ppm	ppm	ppm
Detection Limit	0.1	0.1	30
Analysis Method	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2	FUS-MS-Na_2O_2
MAA Hd	34.6	4.3	40
MAB Hd	37.3	4.1	30
MAC Hd	47.9	4.8	< 30
MAD Hd	38.9	4.4	30
MAE Hd	43.3	4.3	< 30
LPA Hd	6	0.4	30
LPB Hd	6.8	0.8	40
LPC Hd	6.3	0.8	40
LPD Hd	5.1	0.4	40
LPE Hd	8.6	1.2	40
MAMC Hd	39.6	4.1	40
LPMC Hd	7.4	0.5	40
MG1 Hd	33.5	3.5	100
MG2 Hd	37.4	4.4	< 30
MG3 Hd	41.6	4.7	< 30
MG4 Hd	42.4	5.2	30
MG5 Hd	39.2	4.8	30
MG6 Hd	42.6	5.3	< 30
MD1 Hd	37	4.8	< 30
MD2 Hd	38	4	< 30
MD3 Hd	36.3	4.9	< 30
MD4 Hd	34.8	4	< 30
MD5 Hd	44	5	< 30
LG1 Hd	7.2	0.8	40
LG2 Hd	7.5	0.5	60
LG3 Hd	5.3	0.6	70
LG4 Hd	4.7	0.3	< 30
LG5 Hd	7.6	0.5	70
LG6 Hd	3.7	< 0.1	30
LD1 Hd	6.5	0.6	40
LD2 Hd	3.9	0.4	40
LD3 Hd	8.2	0.8	60
LD4 Hd	9.9	0.9	70
LD5 Hd	6.9	0.7	40

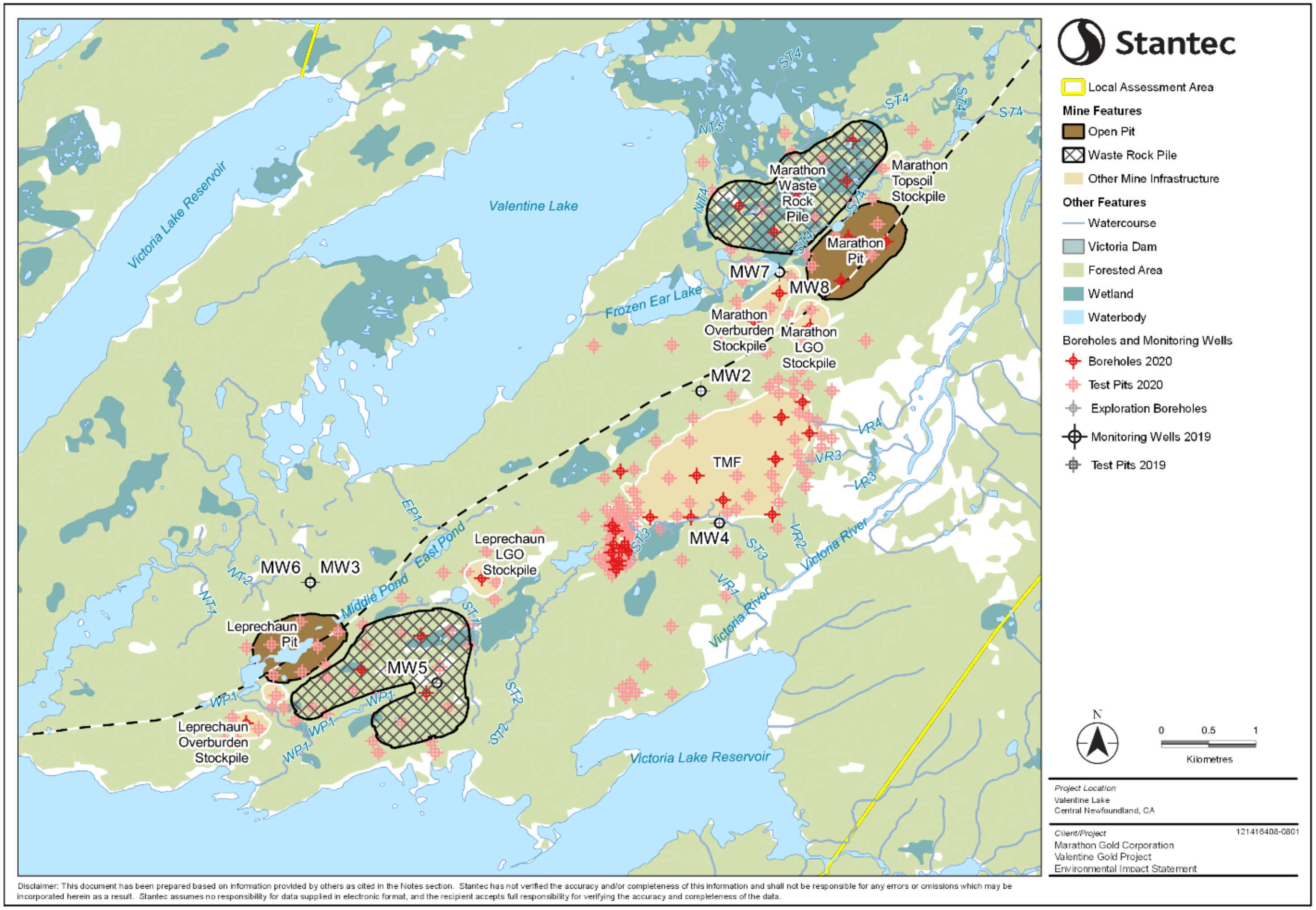
RESPONSE TO IR-26

ID:	**IR-26**
Expert Department or Group:	NRCan-21
Guideline Reference:	Section 7.1
EIS Reference:	Chapter 7 and Baseline hydrology and surface water quality monitoring program (Appendix D Local water quality tables)
Context and Rationale:	Section 7.1 of the EIS Guidelines states that the EIS will present information in sufficient detail to enable the identification of how the project could affect the VCs and the analysis of those effects. Baseline water quality has been monitored at the site since 2011. Upon review of table 7.24 of Chapter 7 of the EIS, the baseline concentrations for a number of elements (including chromium) are high compared to the regional water quality monitoring stations. Currently, the proponent derived local baseline concentrations by pooling all water quality monitoring stations together and calculated a 75th percentile value as baseline water quality. Upon review of Appendix D of the baseline document, high chromium levels appear to have occurred predominantly in 2011 and have often been below the detection limit of 1ppb ever since. The variability in metal concentration depends on many factors and it is likely not appropriate to use baseline metal data in streams to derive a baseline for Valentine and Victoria Lakes.
Information Request:	a. Set baseline metal concentrations for Valentine Lake, Victoria Lake and Victoria River based only on measurements in the given water bodies that will receive effluent discharge. Discuss the baseline water quality for chromium in comparison to the Canadian Water Quality guideline for the protection of aquatic life of 1pbb for hexavalent chromium and 8ppb for trivalent chromium. Assess the need to include chromium as a contaminant of potential concern in the EIS given its toxicity to fish and fish habitat.
Response:	a. As indicated by the reviewer, pooled water quality data was used to describe local Project Area baseline conditions; however, in the assessment of effects on water quality (please refer to the Assimilative Capacity Study presented in Appendix 7C of the EIS and associated effects assessment for surface water quality in Section 7.5.2.3 of the EIS), water quality data was discretized for the small tributaries and ponds from the larger receivers (i.e., Victoria Lake Reservoir, Valentine Lake and Victoria River). As described in the Assimilative Capacity Study, local waterbody/watercourse water quality was used to model the effluent mixing and assimilation at the final discharge point and in the

ID:	**IR-26**
	downstream channel at 100 m and 250 m. Continuing downstream, the model transitioned to what was referred to as the ultimate receiver (i.e., Victoria Lake Reservoir, Valentine Lake or the Victoria River). The baseline water quality data used to model effluent effects in each of the ultimate receivers was from the respective waterbody water quality data (i.e., the entire dataset was not pooled). The effluent assessment used local, smaller watercourse/waterbody water quality to assess effects at and downstream of the final discharge point and used the larger lake/river water quality data to assess the extent of the mixing zone in the downstream ultimate receiver. Please refer to part b) below for further information on chromium (Cr). The groundwater water quality assessment considered Cr with a reportable detection limit (RDL) of 1 ug/L (EIS Baseline Study Appendix [BSA].3, Attachment 3-A, Table C-2) and observed all samples below the RDL. In the dissolved constituent groundwater environment, it is assumed that most Cr is in the more soluble and mobile hexavalent form, thus it is assumed that groundwater quality was below the Cr-6 Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life (CWQG-FAL) threshold of 1 ug/L and Cr-3 CWQG-FAL threshold of 8.9 ug/L. In BSA.3, Attachment 3-C, Table 4.34, regional water quality stations monitoring chromium observed a maximum concentration of 0.37 ug/L, which is below the CWQG-FAL threshold for both Cr-6 and Cr-3. Upon further review of the local water quality presented in BSA.3, Attachment 3-C, it is acknowledged that Cr concentrations appear to be anomalously higher specifically during 2011, the first year of the field monitoring program. In total, 619 samples were collected in the local field program commencing in 2011; 505 of the Cr samples were below detection limit, yet during 2011, some Cr samples in surface water approached 100 ug/L. Additional anomalously high Cr values were observed during the February 6, 2014 sampling event (maximum Cr concentration of 160 ug/L). Such high concentrations were not observed at that same station in subsequent years or sampling events. Unfortunately, as a decade has passed since the sampling was undertaken in 2011, the cause or sources of the anomalies in Cr concentration are not able to be investigated. However, to assess this apparent anomaly, the 2011 Cr samples, as well as the February 6, 2014 data, were parsed from the dataset and the statistical analysis was re-run. The resulting analysis covering the local field monitoring

ID:	**IR-26**
	period extending from 2012 - 2019 had a total of 515 samples with 446 samples below RDL, and a maximum Cr concentration of 19.7 ug/L. If a quantitative value for non-detects is assumed to be 1/2 the RDL (EC 2012), then the mean concentration and 75th percentile for Cr from 2012-2019 was 0.81 ug/L and 0.5 ug/L, respectively, neither of which exceed 1 ug/L, the CWQG-FAL threshold for CR-6. The 75th percentile is calculated to be slightly less than the mean concentration because many of the samples were below detection and were represented by a value of 0.5 ug/L thus skewing the data set towards lower concentrations. Cr was non-detect in local groundwater and well below the 1 ug/L CWQG-FAL Cr-6 threshold in regional surface water quality and in local field-based water quality when the anomalous 2011 years and Feb 6/14 sampling was parsed from the dataset. Cr was also not detected as a parameter of potential concern in the geochemical water quality assessment (Appendix 7-A and 7-B, in the EIS). For the above reasons, Cr was not forwarded as a parameter of potential concern. Reference: Environment Canada (EC). 2012. Metal Mining Technical Guidance for Environmental Effects Monitoring. Environment Canada
Appendix:	None

APPENDIX IR-08.A
IR-08 FIGURE AND TABLE



Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.

Figure IR-08.1 Groundwater Monitoring Wells, Boreholes, and Test Pits at the Valentine Gold Project

Table IR-08.1 Water Level Data

Test Hole ID	Easting (m NAD83 UTM Zone 21)	Northing (m NAD83 UTM Zone 21)	Elevation (m)	Test Hole Depth (m)	Depth to Water Level (m)	Type
20BH-01	489928.4	5357325	384.522	12.27	0.858	Borehole
20BH-02	489963.7	5357270	382.543	13.79	0.353	Borehole
20BH-03	489942.2	5357124	380.135	9.5	0.034	Borehole
20BH-04	490059.8	5357123	380.624	16.08	0.334	Borehole
20BH-05A	490031.1	5357082	380.815	30.4	0.336	Borehole
20BH-05B	490031.4	5357080	380.903	6.4	0.248	Borehole
20BH-06	490094.7	5357089	379.956	9.14	0.498	Borehole
20BH-07	490102.4	5357047	378.923	9.14	0.308	Borehole
20BH-08	489920.2	5357038	380.927	12.19	0.158	Borehole
20BH-09	489944.5	5356940	385.101	9.78	2.739	Borehole
20BH-10	489997.8	5356950	382.165	9.55	0.294	Borehole
20BH-11	489998.6	5356901	383.53	24.54	0.533	Borehole
20BH-12	489967.8	5356862	384.13	18.52	0.5	Borehole
20BH-13	492477.5	5361402	331.826	7.92	0.187	Borehole
20BH-14	492416.4	5360986	332.774	9.6	0.37	Borehole
20BH-15A	491896.1	5360819	339.801	30.63	0.336	Borehole
20BH-15B	491896.1	5360819	339.801	4.57	0.248	Borehole
20BH-16	491272	5360713	334.803	7.52	-0.085	Borehole
20BH-17	491643.1	5360434	345.62	6.4	0.431	Borehole
20BH-18	492430.8	5360379	342.767	12.19	0.474	Borehole
20BH-19	492826.3	5360337	359.195	6.37	0.925	Borehole
20BH-20	492354.9	5359920	362.146	6.33	1.544	Borehole
20BH-21	491701.4	5359788	350.944	10.97	0.398	Borehole
20BH-22	491438.7	5359491	369.825	9.34	0.356	Borehole
20BH-23	492026	5359434	386.363	6.61	0.613	Borehole
20BH-24	491946.3	5358636	361.834	7.86	0.492	Borehole
20BH-25	492019.8	5358304	353.821	6.15	0.298	Borehole
20BH-26A	491720.8	5358475	367.748	30.48	-0.551	Borehole
20BH-26B	491718.3	5358473	367.829	5.77	-0.57	Borehole
20BH-27	491659.7	5358030	357.076	9.24	-0.056	Borehole
20BH-27A	491657.2	5358029	357.236	29.08	-0.133	Borehole
20BH-28	490823.8	5357855	384.545	12.34	0.54	Borehole
20BH-29	491624.6	5357443	340.688	10.97	0.028	Borehole
20BH-30	490762.4	5357410	372.332	10.71	1.115	Borehole
20BH-31	490329.7	5357412	377.465	9.14	0.248	Borehole

Table IR-08.1 Water Level Data

Test Hole ID	Easting (m NAD83 UTM Zone 21)	Northing (m NAD83 UTM Zone 21)	Elevation (m)	Test Hole Depth (m)	Depth to Water Level (m)	Type
20BH-32	490015.1	5357901	414.861	10.57	0.323	Borehole
20BH-33	488545.7	5356767	386.934	10.87	0.592	Borehole
20BH-34	487898.8	5356158	380.224	15.37	0.115	Borehole
20BH-35A	487266.3	5355802	378.359	30.61	0.996	Borehole
20BH-35B	487270.3	5355801	378.25	7.87	0.059	Borehole
20BH-36	487957.2	5355551	362.377	4.67	0.585	Borehole
20BH-37	486046.7	5355231	348.831	7.75	0.689	Borehole
20BH-GLDR-01	491104.1	5357597	368.218	18.31	0.525	Borehole
20TP-01	490003.4	5357586	397.911	2.2	0.3	Test Pit
20TP-02	489872.4	5357491	398.142	2.1	1.1	Test Pit
20TP-03	489980.8	5357490	393.262	2	0.5	Test Pit
20TP-04	490047.5	5357505	390.215	2.2	1.5	Test Pit
20TP-05	489938.1	5357428	391.483	2.3	2.2	Test Pit
20TP-06	490043.9	5357425	385.348	2.6	2	Test Pit
20TP-07	489946.5	5357365	385.964	3.1	0.4	Test Pit
20TP-08	489883.4	5357319	384.667	2.5	2	Test Pit
20TP-09	489970.4	5357312	382.393	3.2	1.5	Test Pit
20TP-10	489920.4	5357274	382.867	2.5	0.5	Test Pit
20TP-100	489641.1	5357423	401.567	3.1	0.6	Test Pit
20TP-101	490389.3	5358221	423.335	0.9	0.4	Test Pit
20TP-102	490785.1	5358461	419.703	0.2	0.1	Test Pit
20TP-103	491192	5358699	407.327	0.3	0.1	Test Pit
20TP-104	490666.9	5356961	379.498	3	0.9	Test Pit
20TP-105	490551.6	5356258	380.565	3.8	1	Test Pit
20TP-106	490265.7	5355844	370.296	4.3	2.9	Test Pit
20TP-107	490563.1	5355538	354.376	2.1		Test Pit
20TP-108	491137.8	5356588	324.519	4.2		Test Pit
20TP-109	491248.3	5357045	344.598	3.4	2.9	Test Pit
20TP-11	490091.6	5357302	380.941	2.85	0.3	Test Pit
20TP-110	491681.7	5357301	328.332	4.1		Test Pit
20TP-111	491976.5	5357738	336.677	2.9	1.1	Test Pit
20TP-112	492251.2	5358248	339.738	2.2	0.6	Test Pit
20TP-113	492256.4	5358754	352.04	4.65	0.6	Test Pit
20TP-114	492615.8	5359287	370.846	4.9	2.5	Test Pit
20TP-115	491925.7	5358975	384.648	1.7	1.1	Test Pit

Table IR-08.1 Water Level Data

Test Hole ID	Easting (m NAD83 UTM Zone 21)	Northing (m NAD83 UTM Zone 21)	Elevation (m)	Test Hole Depth (m)	Depth to Water Level (m)	Type
20TP-116	491569.1	5359163	395.917	2.9	1.6	Test Pit
20TP-117	491081.7	5359247	382.373	2.7	1.5	Test Pit
20TP-118	490559.4	5359238	370.754	3.6		Test Pit
20TP-119	491803.3	5359560	374.458	4.6		Test Pit
20TP-12	490054.2	5357250	381.227	3.9	0.3	Test Pit
20TP-120	491980.6	5360205	344.05	3.25	2	Test Pit
20TP-121	492461.7	5360749	334.004	2.8	0.6	Test Pit
20TP-122	492787.2	5361113	328.906	2.43	0.5	Test Pit
20TP-123	490746.9	5358225	406.353	0.4		Test Pit
20TP-13	490112	5357228	380.685	4.8	0.5	Test Pit
20TP-14	490156.9	5357319	380.325	1.85		Test Pit
20TP-15	490142.2	5357151	379.762	4.9	2.5	Test Pit
20TP-16	489900.1	5357182	380.877	2.7	0.3	Test Pit
20TP-17	489892.1	5357087	379.607	4.2	1.3	Test Pit
20TP-18	489864.3	5357004	380.383	3.5	1.4	Test Pit
20TP-19	489784.6	5356976	380.76	3.4	1.8	Test Pit
20TP-20	489853.1	5356913	381.66	3.5	3.4	Test Pit
20TP-21	489882.5	5356881	383.023	4.3	1.7	Test Pit
20TP-22	489926.4	5356803	384.547	4.6	2.5	Test Pit
20TP-23	490074.7	5356910	382.219	4.8	2.5	Test Pit
20TP-24	490127.7	5356965	379.677	2.8	1.5	Test Pit
20TP-25	490041.5	5357009	380.953	4.8	2.5	Test Pit
20TP-26	489979.1	5357007	385.032	5.2	4	Test Pit
20TP-27	489732.5	5359229	357.388	1.5		Test Pit
20TP-28	490034	5355603	350.103	3.9	2.3	Test Pit
20TP-29	490114.3	5355651	354.409	4.2	1.1	Test Pit
20TP-30	490072.3	5355515	344.99	4.2	1	Test Pit
20TP-31	490174.8	5355555	349.215	4.3	3.5	Test Pit
20TP-32	490099.6	5357395	382.045	2.2	0.7	Test Pit
20TP-33	492159	5361201	333.987	2.5	0.7	Test Pit
20TP-34	491512.2	5360668	335.775	2.1	0.35	Test Pit
20TP-35	492074.7	5360588	340.625	2.1	1.6	Test Pit
20TP-36	492741.4	5360522	344.476	3.93	3.1	Test Pit
20TP-37	492680.3	5360195	356.502	0.85	0.2	Test Pit
20TP-38	492296.9	5360387	334.751	3.2	1.5	Test Pit

Table IR-08.1 Water Level Data

Test Hole ID	Easting (m NAD83 UTM Zone 21)	Northing (m NAD83 UTM Zone 21)	Elevation (m)	Test Hole Depth (m)	Depth to Water Level (m)	Type
20TP-39	492042.9	5360080	345.198	3.8	1.2	Test Pit
20TP-40	491826.3	5359953	344.058	2.2	1.2	Test Pit
20TP-41	491603.7	5359637	358.837	3.2	0.4	Test Pit
20TP-42	491273.3	5359582	351.768	4.9	0.3	Test Pit
20TP-43	492036.4	5359612	375.331	1.5	0.1	Test Pit
20TP-44	491939.2	5359272	388.515	4.5	0.5	Test Pit
20TP-45	491594.4	5358799	391.215	1.7	0.7	Test Pit
20TP-46	491695.5	5358728	381.772	4.7	1.1	Test Pit
20TP-47	491855.2	5358724	372.779	4.3	1.8	Test Pit
20TP-48	491909.5	5358527	360.782	4.8	0.65	Test Pit
20TP-49	492012.3	5358476	357.313	1.2	1.2	Test Pit
20TP-50	491460.4	5358463	383.27	3	1	Test Pit
20TP-51	492103.8	5358428	353.098	2.4	1	Test Pit
20TP-52	491861.2	5358239	358.088	2	0.3	Test Pit
20TP-53	491896.9	5358081	353.737	1.2	1.6	Test Pit
20TP-54	491924.9	5357964	349.413	1.2	0.2	Test Pit
20TP-55	491618.7	5357867	356.639	1.1	0.1	Test Pit
20TP-56	491251.6	5357853	369.049	1.3	0.3	Test Pit
20TP-57	490529.2	5357829	394.874	1.4	0.4	Test Pit
20TP-58	491652.4	5357731	351.118	2.4	0.2	Test Pit
20TP-59	490153.1	5357684	398.901	1.5	0.7	Test Pit
20TP-60	490191.4	5357573	388.457	0.95	0.5	Test Pit
20TP-61	490194	5357465	384.143	3.1	0.4	Test Pit
20TP-62	490440	5357292	375.341	2.1	0.6	Test Pit
20TP-63	490615.4	5357427	375.865	3.2	0.5	Test Pit
20TP-64	490749.8	5357565	375.431	5.1	1.4	Test Pit
20TP-65	491145.6	5357467	366.418	4.2	1.2	Test Pit
20TP-66	491242	5357500	362.26	2.7	2.2	Test Pit
20TP-67	491375.6	5357637	363.097	2.1	1.3	Test Pit
20TP-68	491694.6	5357571	342.388	2.5	1.2	Test Pit
20TP-69	490160	5357919	409.883	0.4	0.1	Test Pit
20TP-70	489846.2	5357828	421.585	0.6	0.2	Test Pit
20TP-71	488384.6	5356839	392.615	1.6	0.5	Test Pit
20TP-72	488700.3	5356722	384.758	1.9	1.2	Test Pit
20TP-73	488202.4	5356208	375.953	3.1	1.3	Test Pit

Table IR-08.1 Water Level Data

Test Hole ID	Easting (m NAD83 UTM Zone 21)	Northing (m NAD83 UTM Zone 21)	Elevation (m)	Test Hole Depth (m)	Depth to Water Level (m)	Type
20TP-74	487690.7	5356178	385.475	4.3	0.8	Test Pit
20TP-75	487318.7	5356065	389.193	1.8	1.6	Test Pit
20TP-76	488099.9	5355824	364.985	3.7	0.7	Test Pit
20TP-77	487596.6	5355790	366.922	3.8	2.5	Test Pit
20TP-78	486890.6	5355715	375.308	3.5	2	Test Pit
20TP-79	487179.3	5355588	364.791	3.4	2	Test Pit
20TP-80	486750.3	5355402	356.527	1.7	0.3	Test Pit
20TP-81	488186.4	5355399	350.406	2.9	1.3	Test Pit
20TP-82	487696.8	5355246	348.229	4.5	0.9	Test Pit
20TP-83	486616.8	5356305	404.321	0.6	0.3	Test Pit
20TP-84	486406	5356253	398.283	0.4		Test Pit
20TP-85	486804.5	5356047	391.6	0.8	0.1	Test Pit
20TP-86	486335.5	5355739	385.001	2.7	1.4	Test Pit
20TP-87	486366.1	5355525	373.952	2.8	0.7	Test Pit
20TP-88	485899.9	5355291	365.5	1.2	0.7	Test Pit
20TP-89	486177.7	5355172	346.456	2.2	1.3	Test Pit
20TP-90	487019	5356201	402.174	1	0.2	Test Pit
20TP-91	486313.4	5356065	388.018	2.4	0.7	Test Pit
20TP-92	486639.4	5355774	387.044	3.5	0.6	Test Pit
20TP-93	486321.5	5355393	358.805	3.3	0.5	Test Pit
20TP-94	486891	5355843	395.207	0.9	0.5	Test Pit
20TP-95	487287.1	5356273	399.401	1.2	0.6	Test Pit
20TP-96	487697.9	5356560	390.067	2.2	0.3	Test Pit
20TP-97	488138.7	5356826	391.657	0.8	0.3	Test Pit
20TP-98	488595.6	5357051	399.783	4.3	0.8	Test Pit
20TP-99	489133	5357244	401.87	2.8	0.8	Test Pit
20TP-GLDR-01	491993.5	5357882	343.385	2.7	0.8	Test Pit
20TP-GLDR-02	492048.2	5358044	344.699	1.9	0.6	Test Pit
20TP-GLDR-03	492146	5358149	341.983	2.3	0.9	Test Pit
20TP-GLDR-04	492147	5358275	348.649	1.8	0.8	Test Pit
20TP-GLDR-05	492007.8	5358814	370.563	5.3	1.4	Test Pit
20TP-GLDR-06	491849.4	5358860	380.933	2.7	1.8	Test Pit
20TP-GLDR-07	491688.7	5358871	389.709	2.6	0.3	Test Pit
20TP-STAN-01	490889.9	5361176	327.881	5.3	1	Test Pit
20TP-STAN-02	490988.1	5360867	329.812	4.6		Test Pit

Table IR-08.1 Water Level Data

Test Hole ID	Easting (m NAD83 UTM Zone 21)	Northing (m NAD83 UTM Zone 21)	Elevation (m)	Test Hole Depth (m)	Depth to Water Level (m)	Type
20TP-STAN-03	491756.8	5361485	327.724	5.1		Test Pit
20TP-STAN-04	491834.5	5361280	328.991	3		Test Pit
20TP-STAN-05	493105.3	5361521	317.703	2.5		Test Pit
20TP-STAN-06	493264.8	5361359	313.155	2.2		Test Pit
20TP-STAN-07	492686.9	5360795	330.672	4.3		Test Pit
20TP-STAN-08	491245.9	5359704	345.342	3.9		Test Pit
20TP-STAN-09	491305.5	5359922	338.473	4.9		Test Pit
20TP-STAN-10	491372.7	5360132	338.687	3.5		Test Pit
20TP-STAN-11	491182.9	5360254	338.343	2		Test Pit
20TP-STAN-12	488678.3	5356539	378.298	1.1		Test Pit
20TP-STAN-13	488416.6	5356281	372.951	2.6		Test Pit
20TP-STAN-14	488419.9	5356057	369.081	4.5		Test Pit
20TP-STAN-15	488050.5	5354921	326.089	4.2		Test Pit
20TP-STAN-16	488002.8	5355036	336.671	4.2		Test Pit
20TP-STAN-17	487449.9	5354920	342.002	0.9		Test Pit
20TP-STAN-18	487391.9	5355042	349.28	4.6		Test Pit
20TP-STAN-19	487406.4	5355535	354.682	1.7		Test Pit
20TP-STAN-20	486894.6	5355327	355.892	0.9		Test Pit
20TP-STAN-21	486564.3	5355258	343.848	1.3		Test Pit
20TP-STAN-22	486447.5	5355392	355.017	4.1		Test Pit
20TP-STAN-23	485957.2	5355050	341.244	4.1		Test Pit
20TP-STAN-24	485814.6	5355046	342.2	3.3		Test Pit
20TP-STAN-25	486050.5	5356035	386.646	3.5		Test Pit

APPENDIX IR-13.A
IR-13 FIGURES AND TABLES

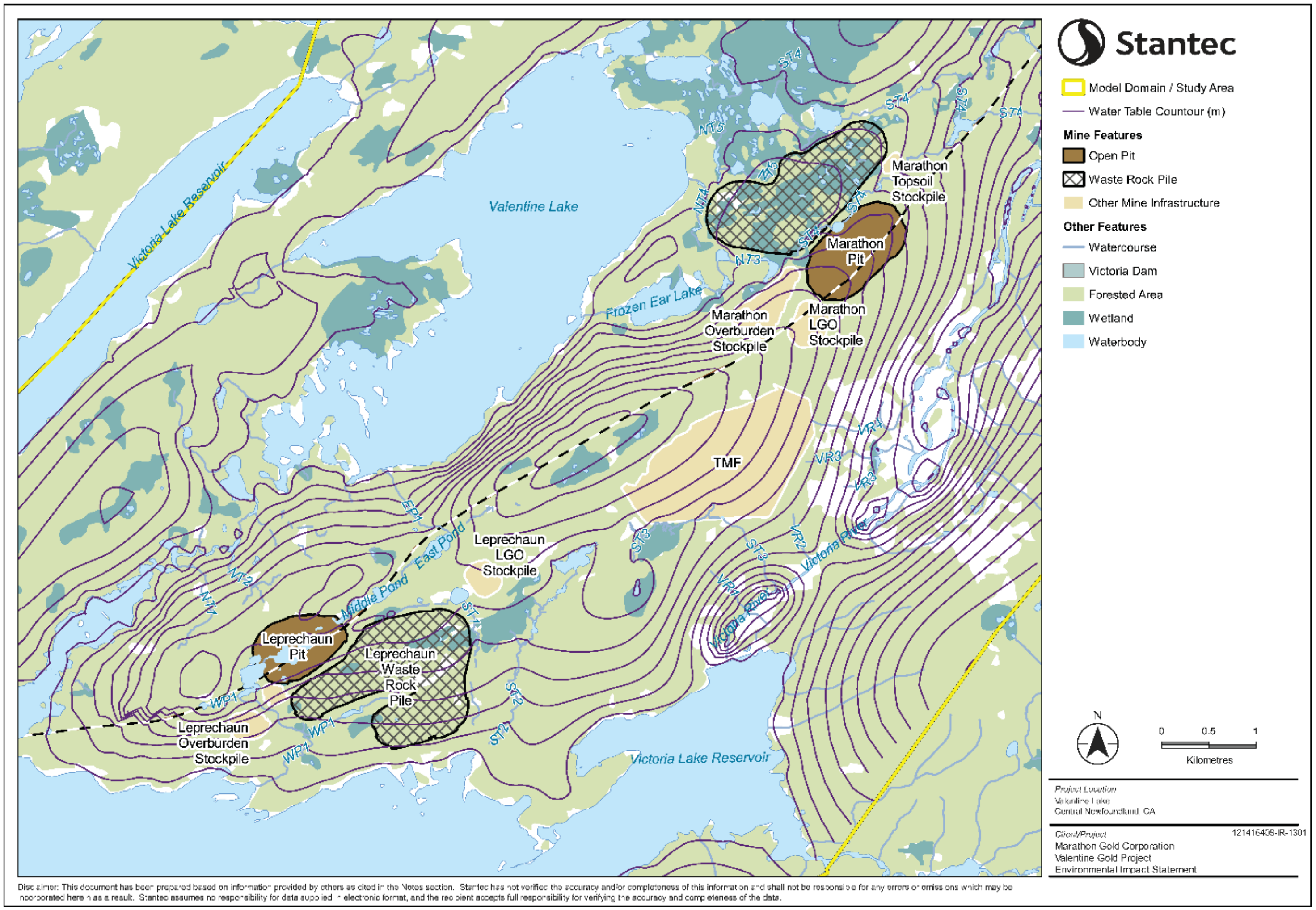


Figure IR-13.1 Baseline water table elevation contours with enhanced permeability fault

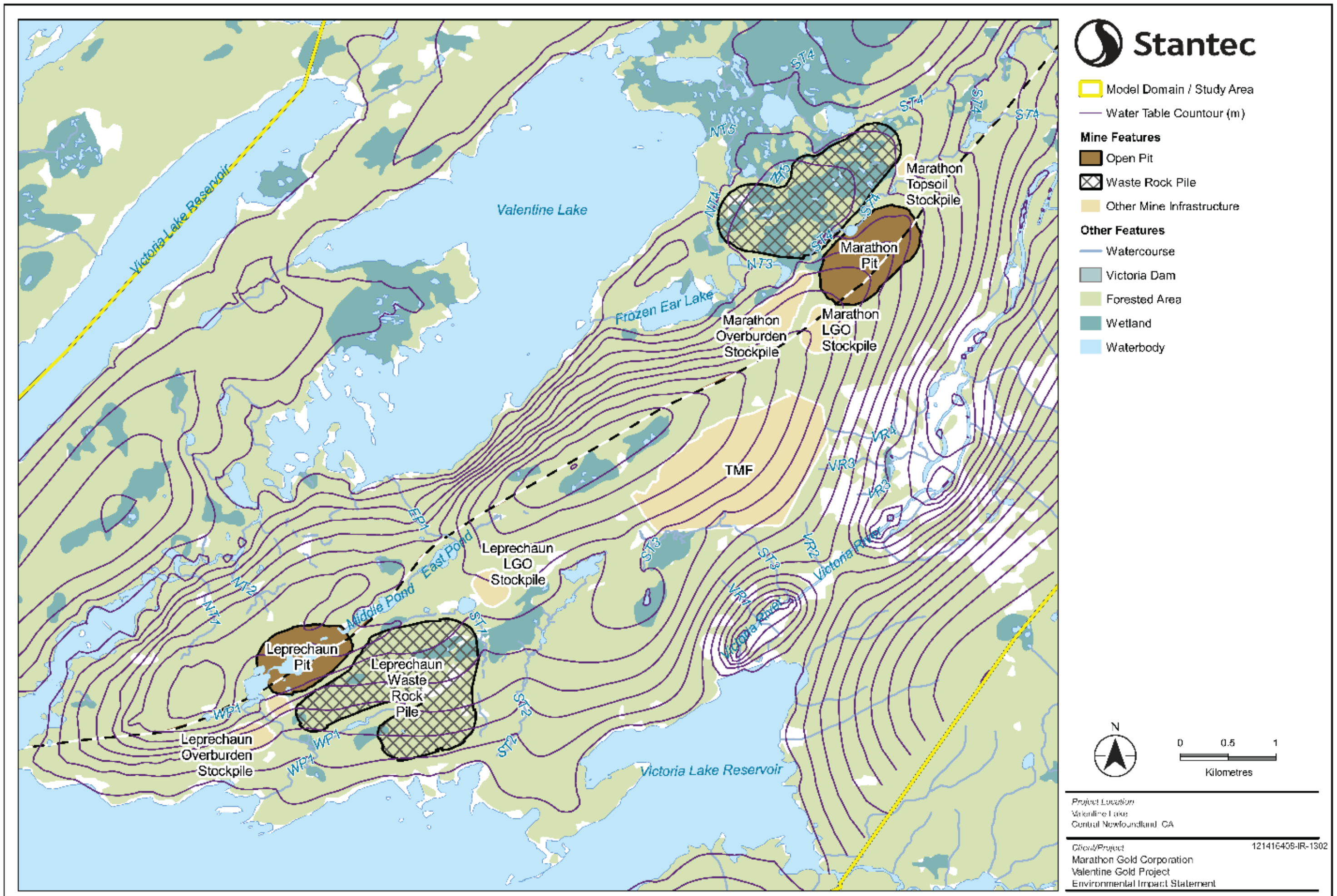


Figure IR-13.2 Baseline water table elevation contours with reduced permeability fault

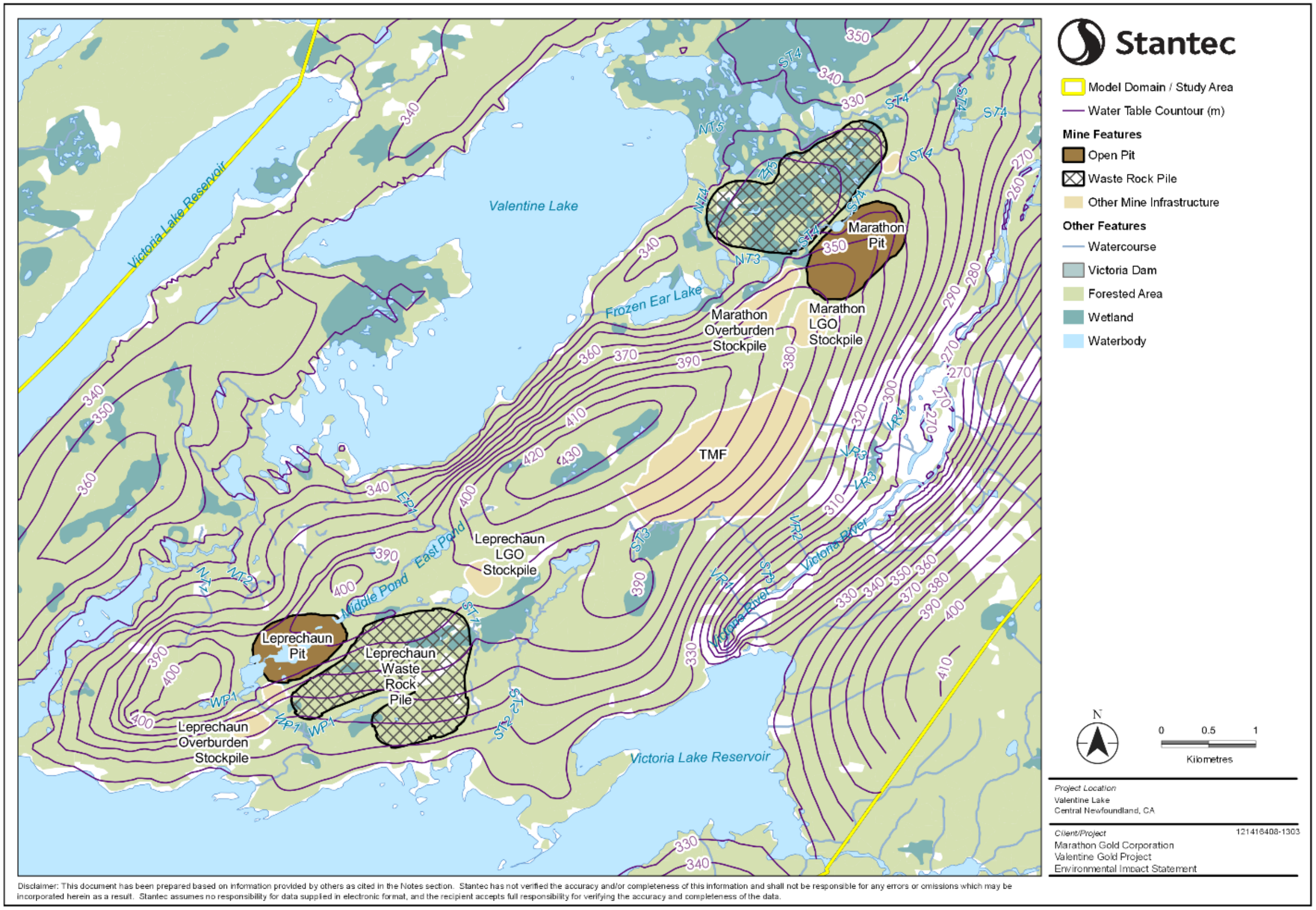


Figure IR-13.3 Water table elevation contours at end of operation with enhanced permeability fault

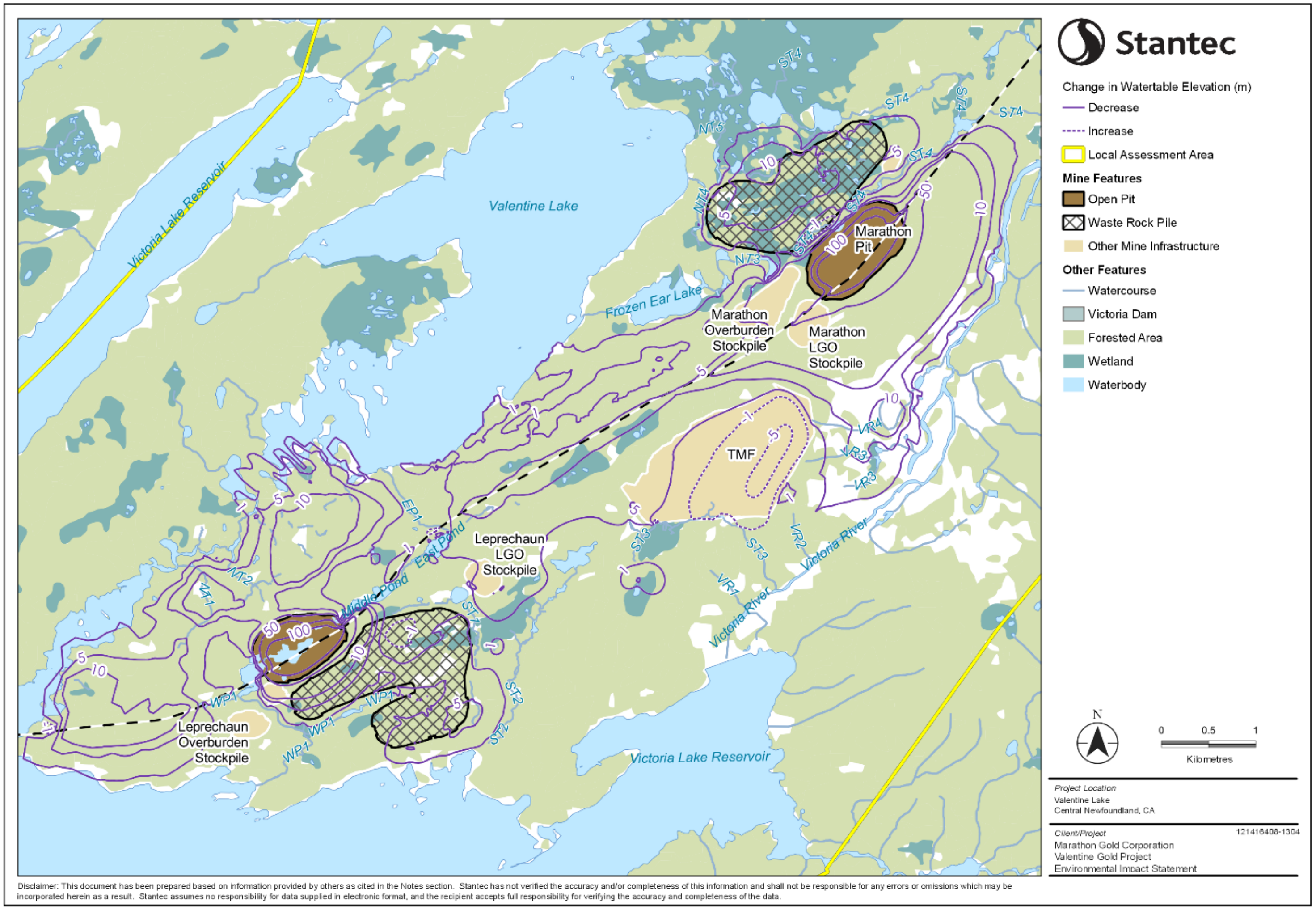


Figure IR-13.4 Change in water table elevation at end of operation with enhanced permeability fault

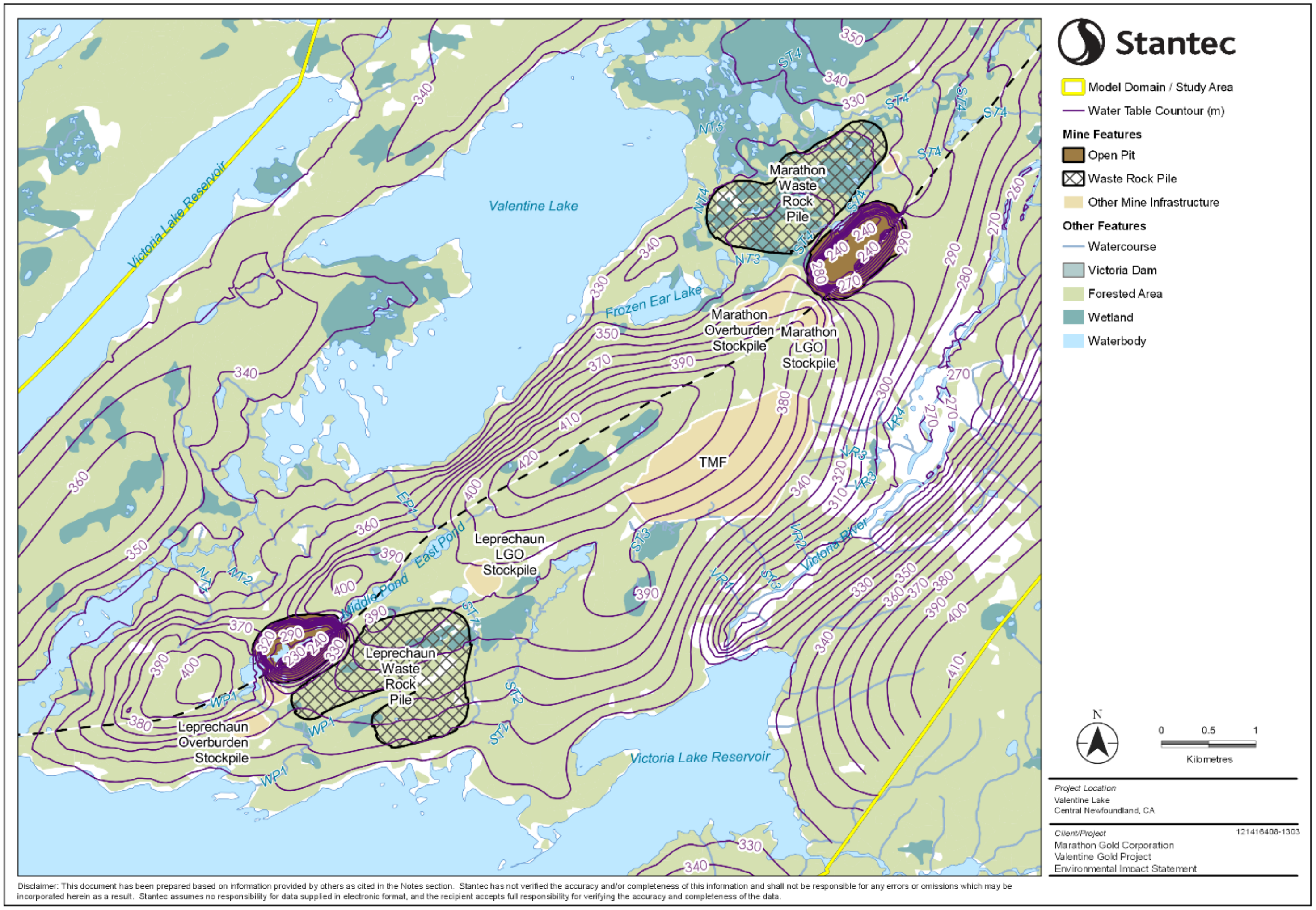


Figure IR-13.5 Water table elevation contours at end of operation with reduced permeability fault

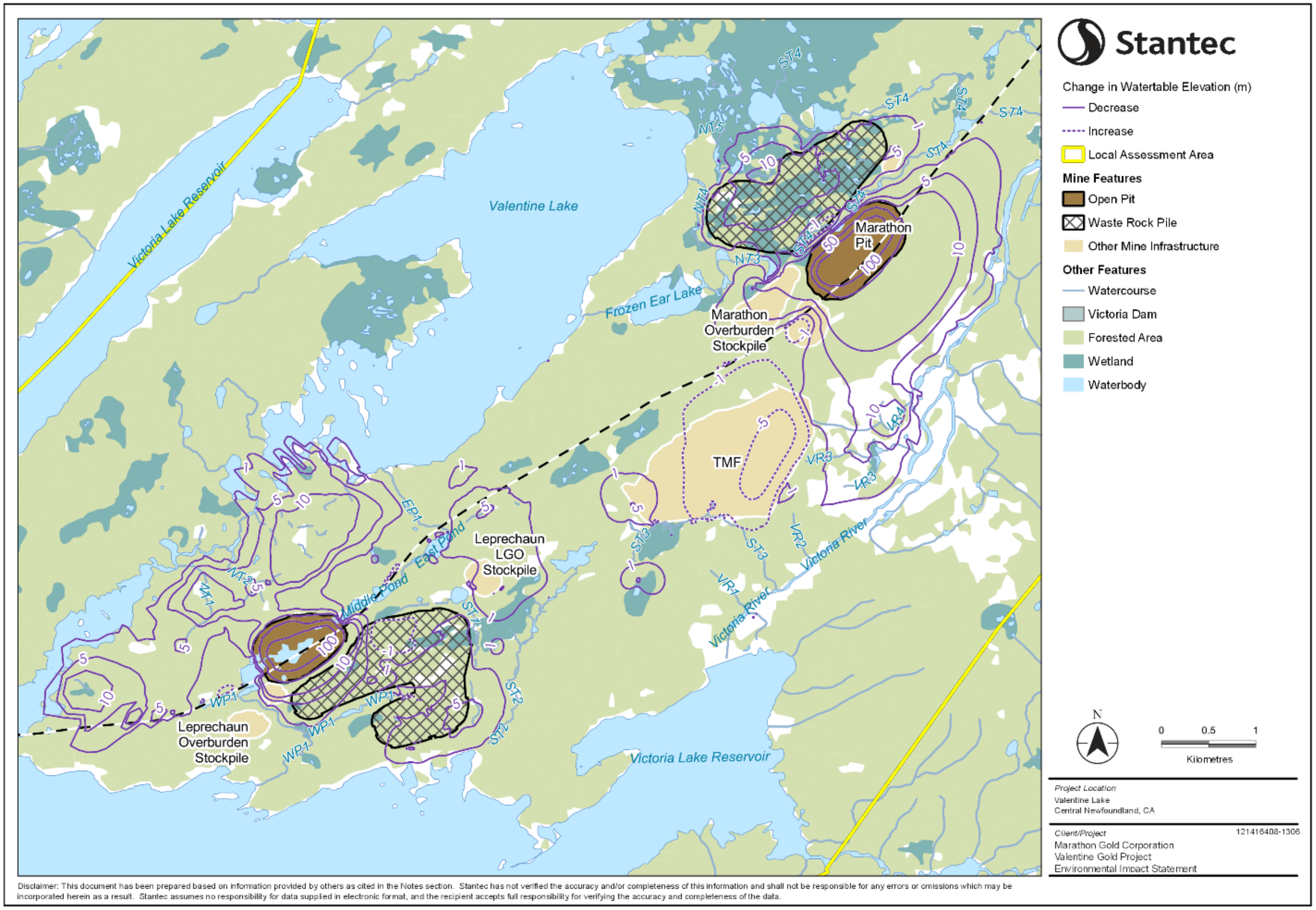
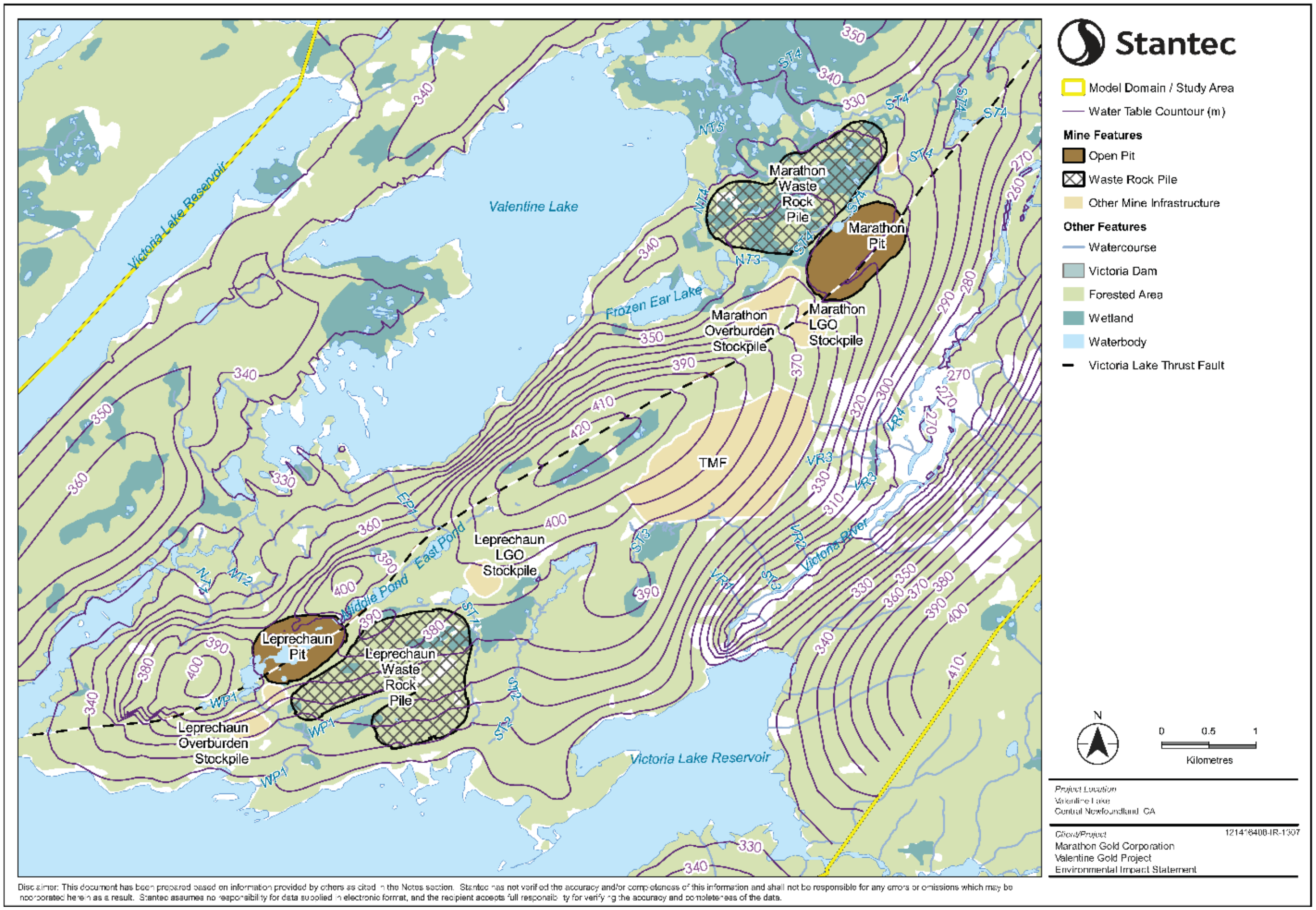


Figure IR-13.6 Change in water table elevation at end of operation with reduced permeability fault



Project Location
Valentine Lake
Central Newfoundland, CA

Client/Project
Marathon Gold Corporation
Valentine Gold Project
Environmental Impact Statement

121416408-IR-1307

Figure IR-13.7 Water table elevation contours following closure with enhanced permeability fault

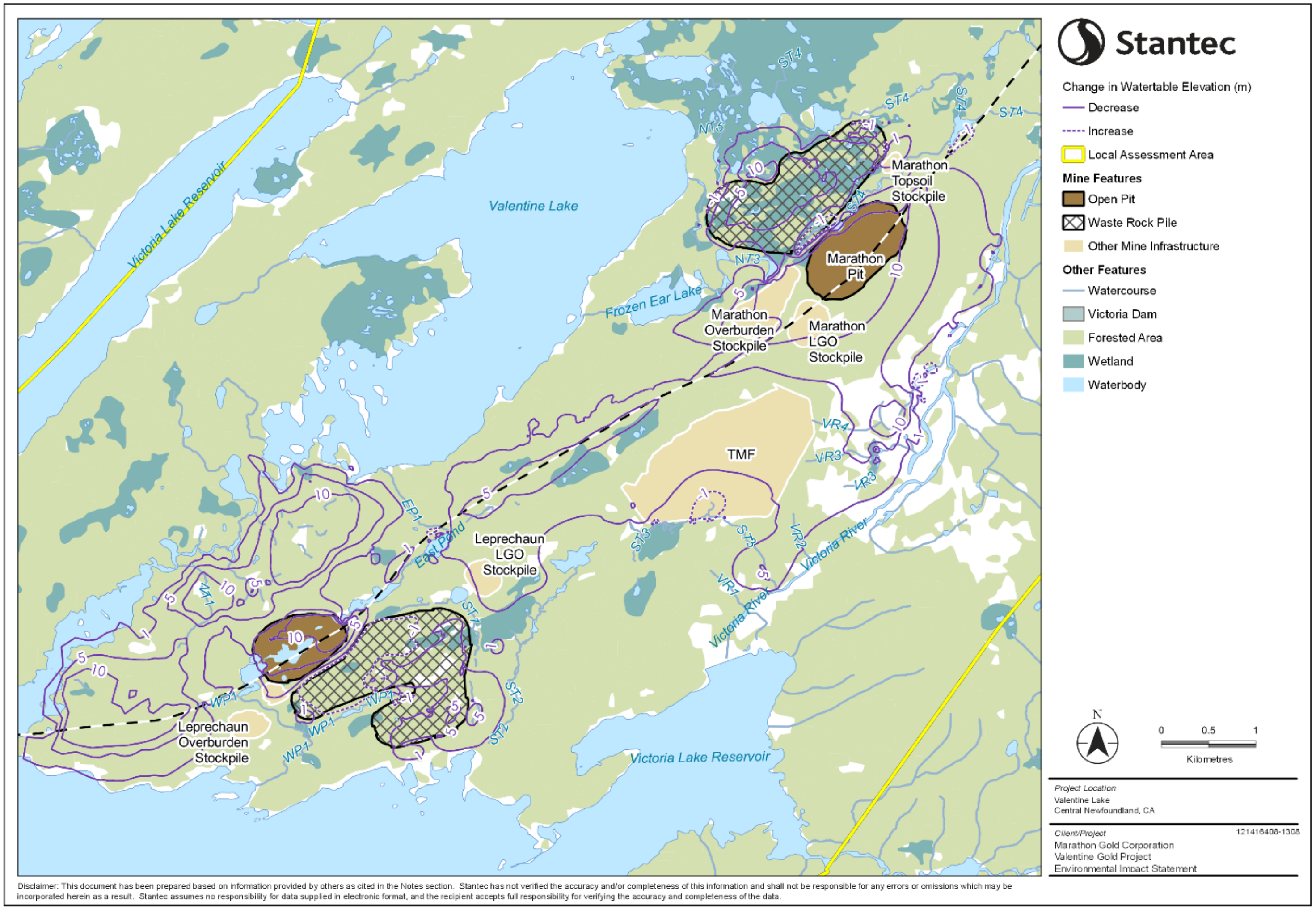


Figure IR-13.8 Change in water table elevation following closure with enhanced permeability fault

Groundwater elevation and drawdown maps for the post-closure conditions for the reduced permeability fault scenarios are presented in Figures IR-13-9 and IR-13-10, respectively.

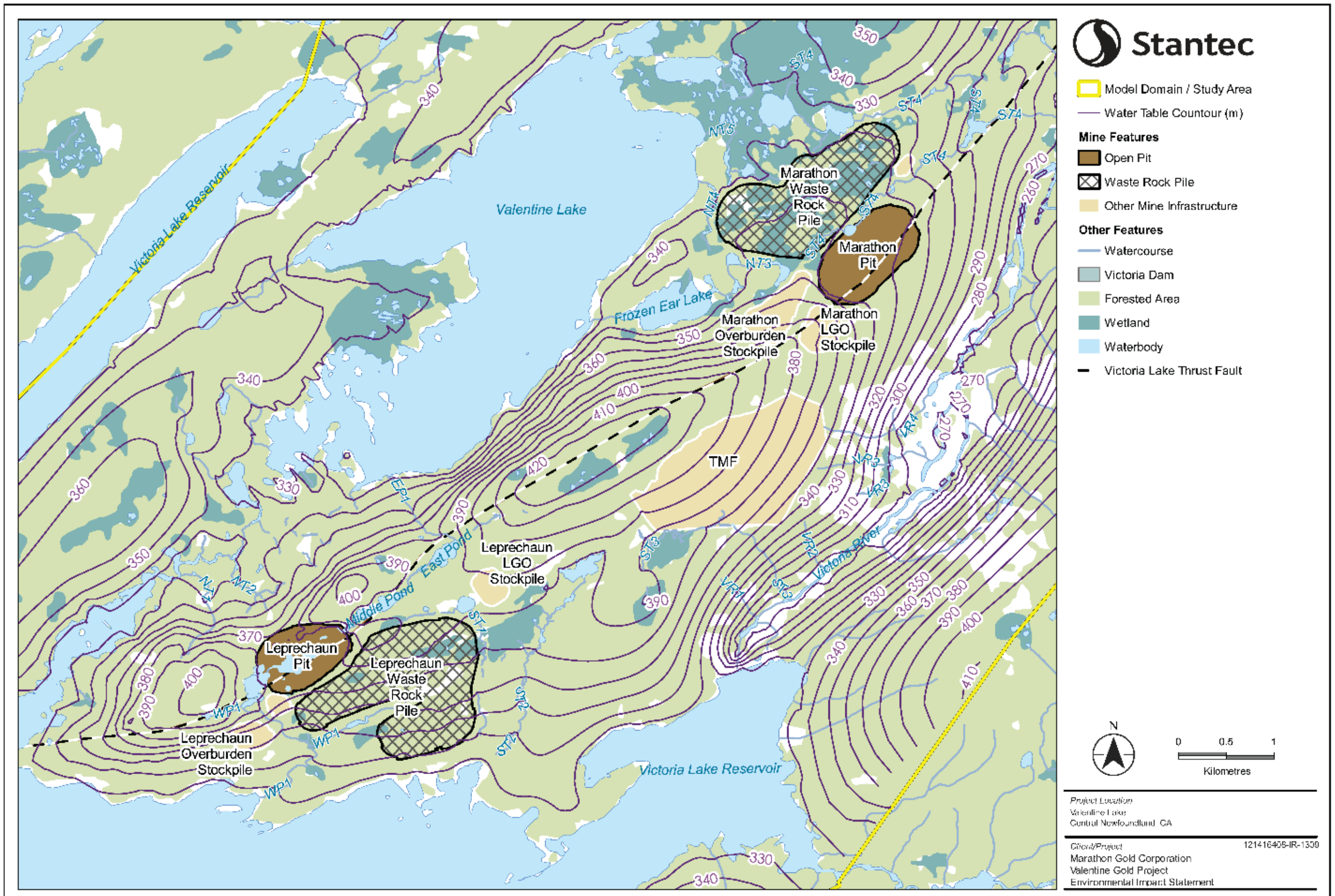


Figure IR-13.9 Water table elevation contours following closure with reduced permeability fault

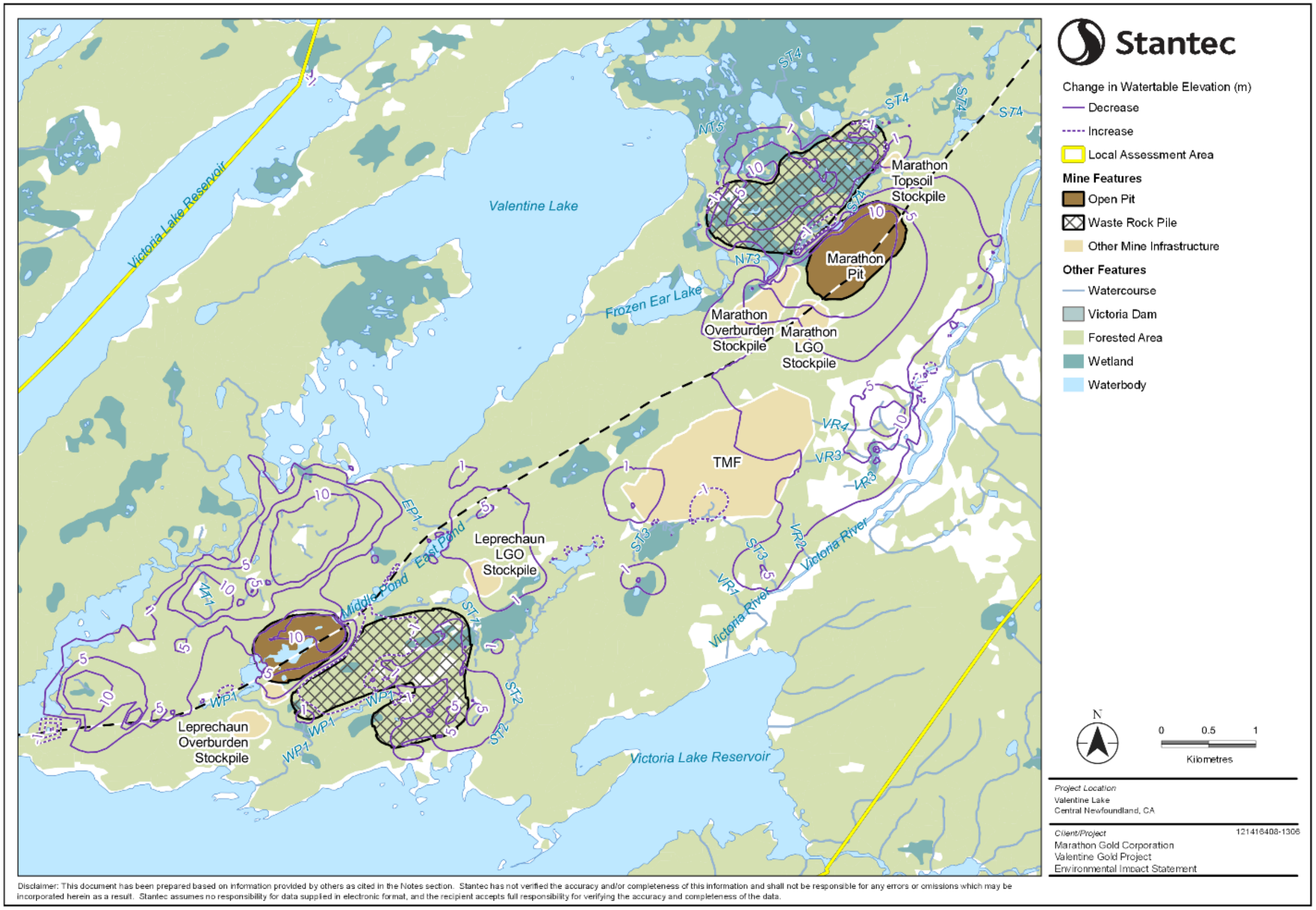


Figure IR-13.10 Change in water table elevation following closure with reduced permeability fault

Table IR-13-1 Estimated Groundwater Discharge to Water Features for Operations Phase

Water Feature	Net Flow from Groundwater to Feature (m^3/d)		
	Operation	Operation with Enhanced Permeability Faults	Operation with Reduced Permeability Faults
Unnamed Tributary to Victoria Lake Reservoir NT1	623.7	608.4	619.7
Unnamed Tributary to Victoria Lake Reservoir NT2	768.6	768	768.5
Frozen Ear Lake and Tributaries NT3	2349.8	2132.2	2352.3
Unnamed Tributary to Valentine Lake NT4	173	173	173
Unnamed Tributary to Valentine Lake NT5	367.6	367.5	367.6
Middle and East Pond and Tributaries EP1	547.3	-1475.9	516.8
West Pond and Tributaries WP1	751.6	-3430.2	689
Unnamed Tributary to Victoria Lake Reservoir ST1	614.9	598.6	614.8
Unnamed Tributary to Victoria Lake Reservoir ST2	2469.3	2441.8	2468.8
Unnamed Tributary to Victoria River ST3	208.1	173.4	207.2
Unnamed Tributary to Victoria River ST4	3113.4	2467.8	3099.3
Unnamed Tributary to Victoria River VR1	206.4	206.4	206.4
Unnamed Tributary to Victoria River VR2	387	385.6	386.9
Unnamed Tributary to Victoria River VR3	962.3	931.4	960.7
Unnamed Tributary to Victoria River VR4	1947.4	1753.2	1930
Victoria River	19748.8	19516.3	19764.9

Table IR-13-2 Estimated Groundwater Discharge to Water Features for Operations Phase

Water Feature	Net Flow from Groundwater to Feature (m^3/d)		
	Post-Closure	Post-Closure with Enhanced Permeability Faults	Post-Closure with Reduced Permeability Faults
Unnamed Tributary to Victoria Lake Reservoir NT1	627	606.7	618
Unnamed Tributary to Victoria Lake Reservoir NT2	821.7	783.6	784.1
Frozen Ear Lake and Tributaries NT3	2442.4	2345.8	2460.5
Unnamed Tributary to Valentine Lake NT4	325.5	338.7	338.7
Unnamed Tributary to Valentine Lake NT5	548.4	591.1	591.1
Middle and East Pond and Tributaries EP1	606.5	604.5	618.2
West Pond and Tributaries WP1	1621.2	951.9	1620.5
Unnamed Tributary to Victoria Lake Reservoir ST1	916.1	911.5	916.8
Unnamed Tributary to Victoria Lake Reservoir ST2	2513.4	2484.6	2512
Unnamed Tributary to Victoria River ST3	850.9	820.9	849.6
Unnamed Tributary to Victoria River ST4	3691.3	3702.8	3675.9
Unnamed Tributary to Victoria River VR1	206.3	206.3	206.3
Unnamed Tributary to Victoria River VR2	360.6	356.5	360.3
Unnamed Tributary to Victoria River VR3	888.4	870.1	887.4
Unnamed Tributary to Victoria River VR4	2014.7	1979.5	2012.5
Victoria River	19882.9	19948.8	19935.3

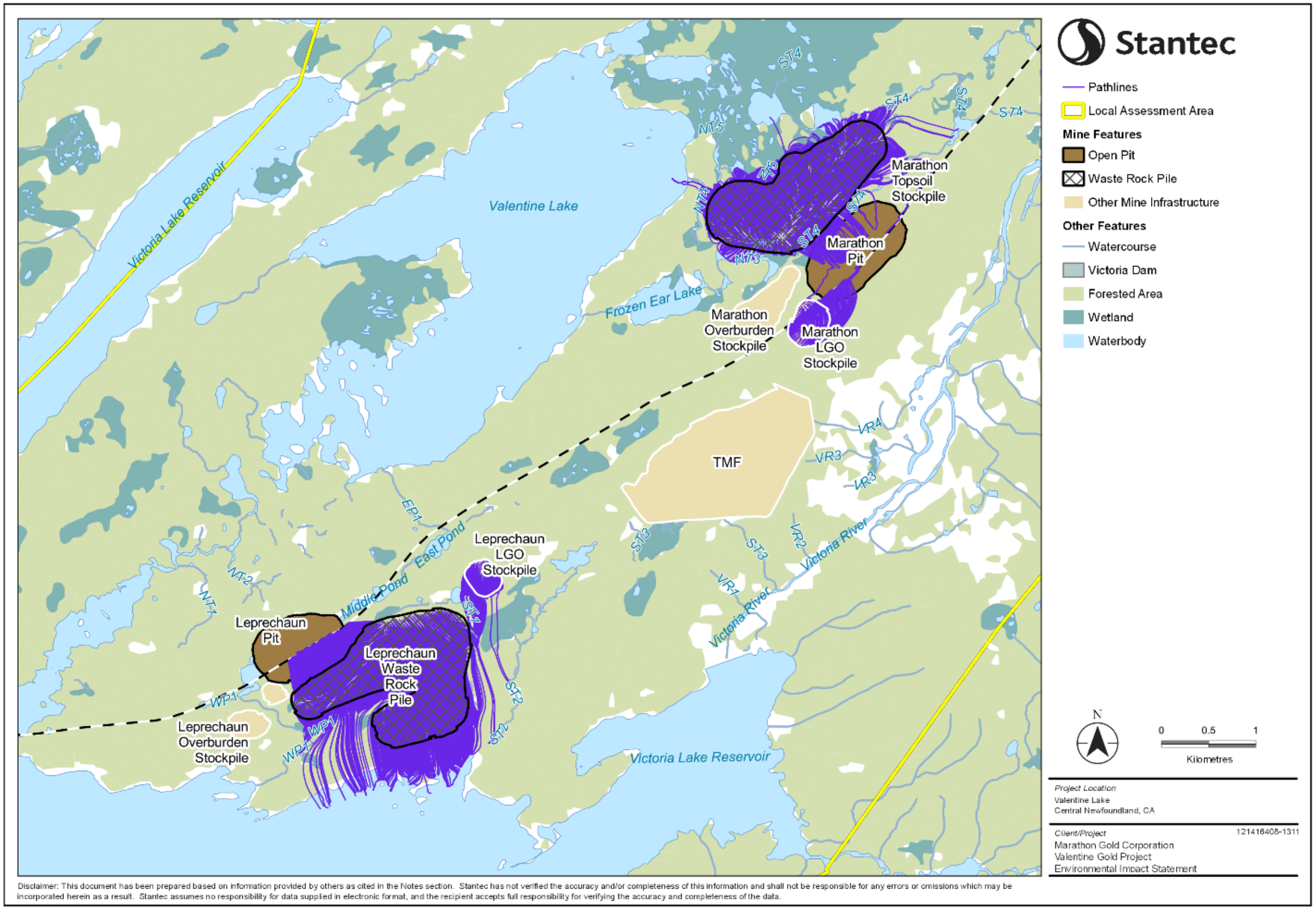


Figure IR-13.11 Particle traces illustrating flow paths from Waste Rock Piles and LGO Stockpiles at end of operation with enhanced permeability fault

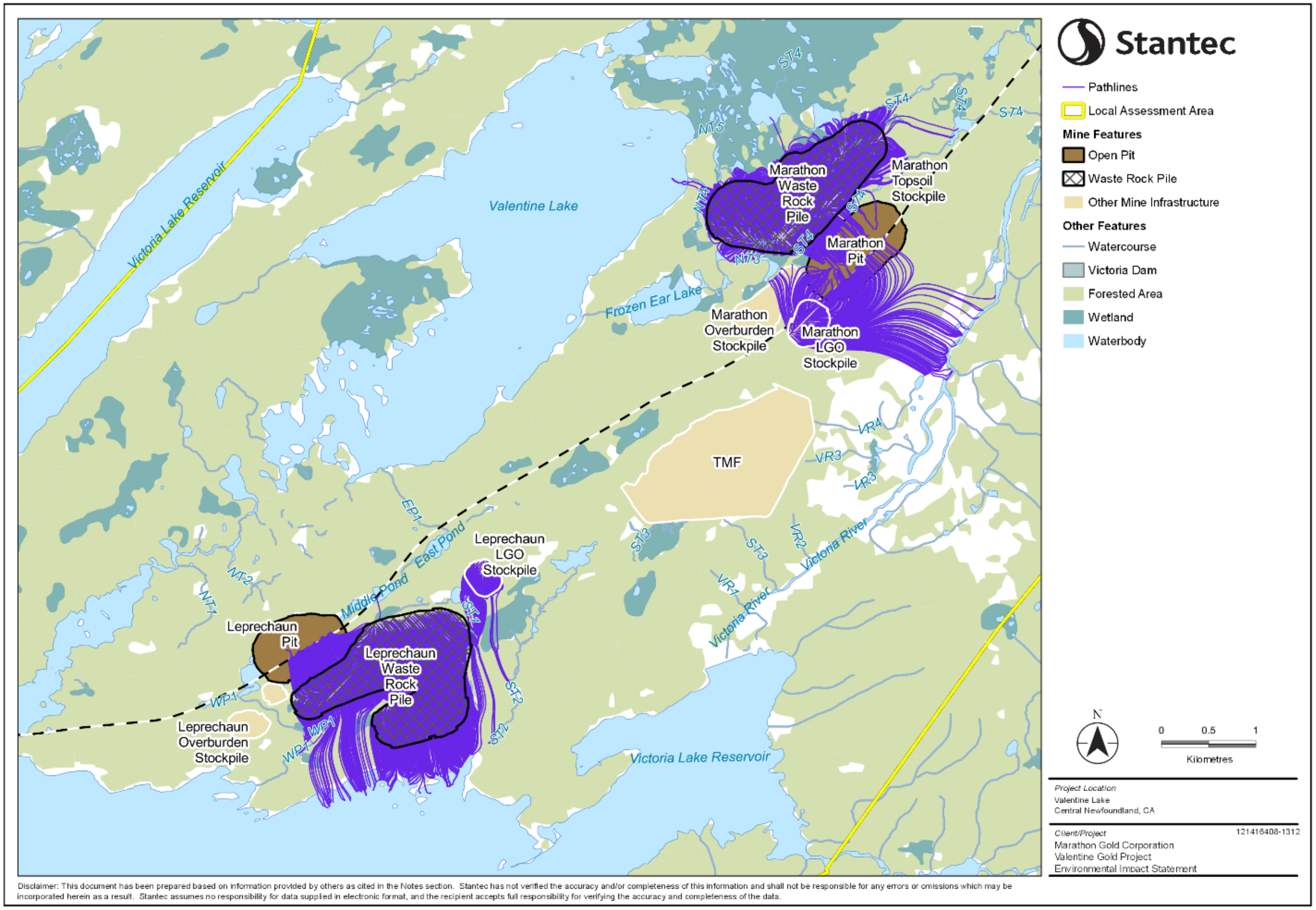


Figure IR-13.12 **Particle traces illustrating flow paths from Waste Rock Piles and LGO Stockpiles at end of operation with reduced permeability fault**

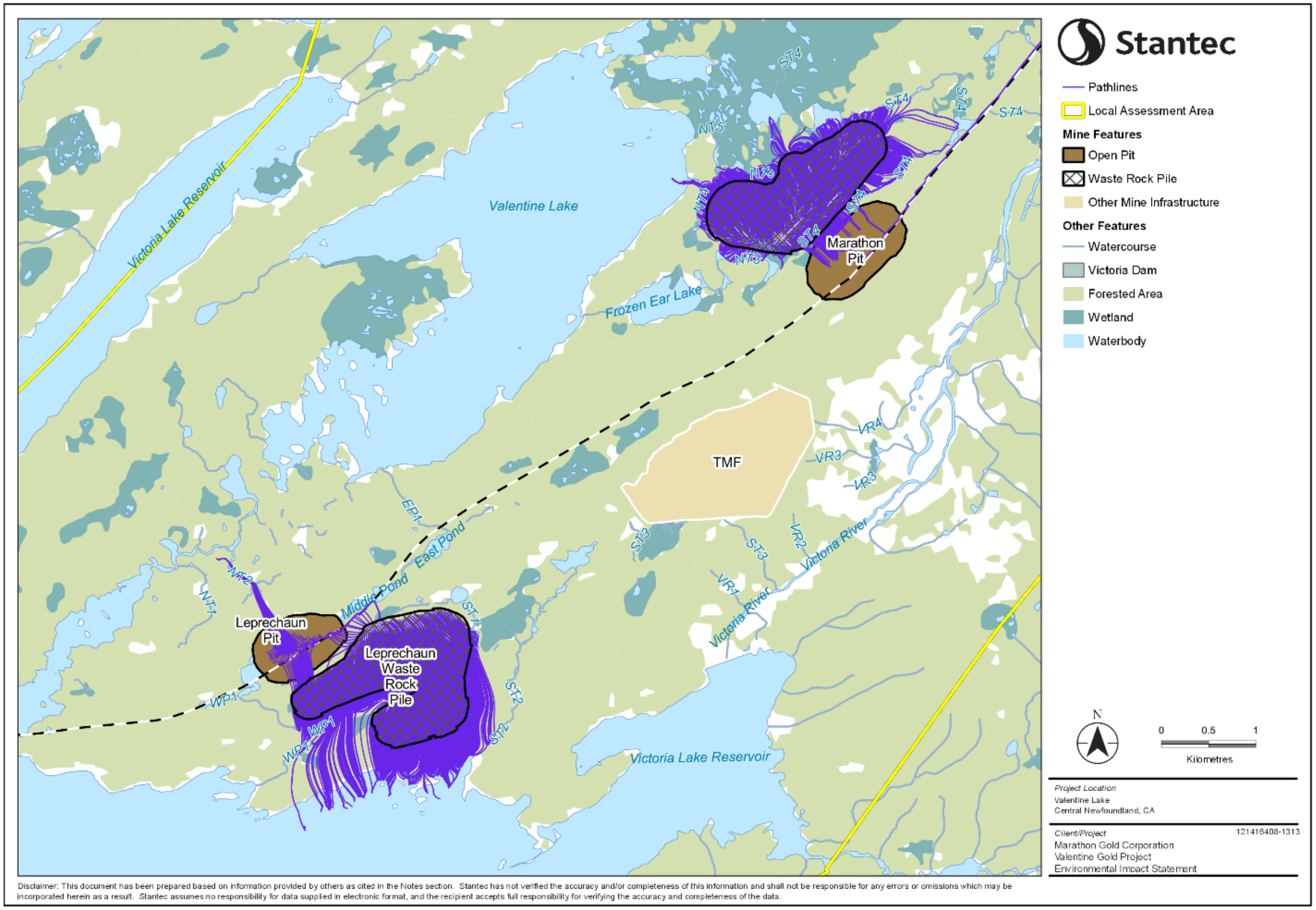
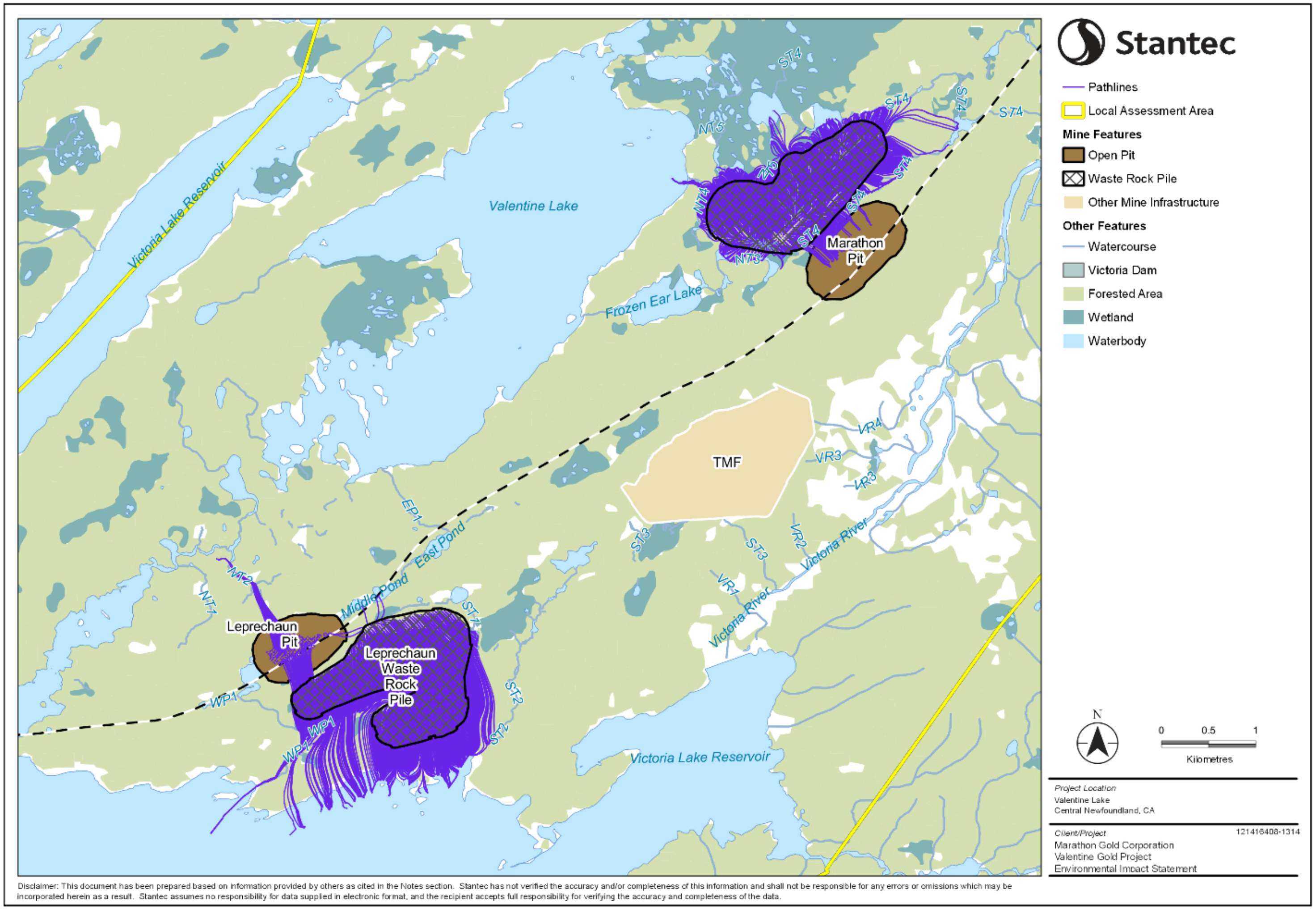


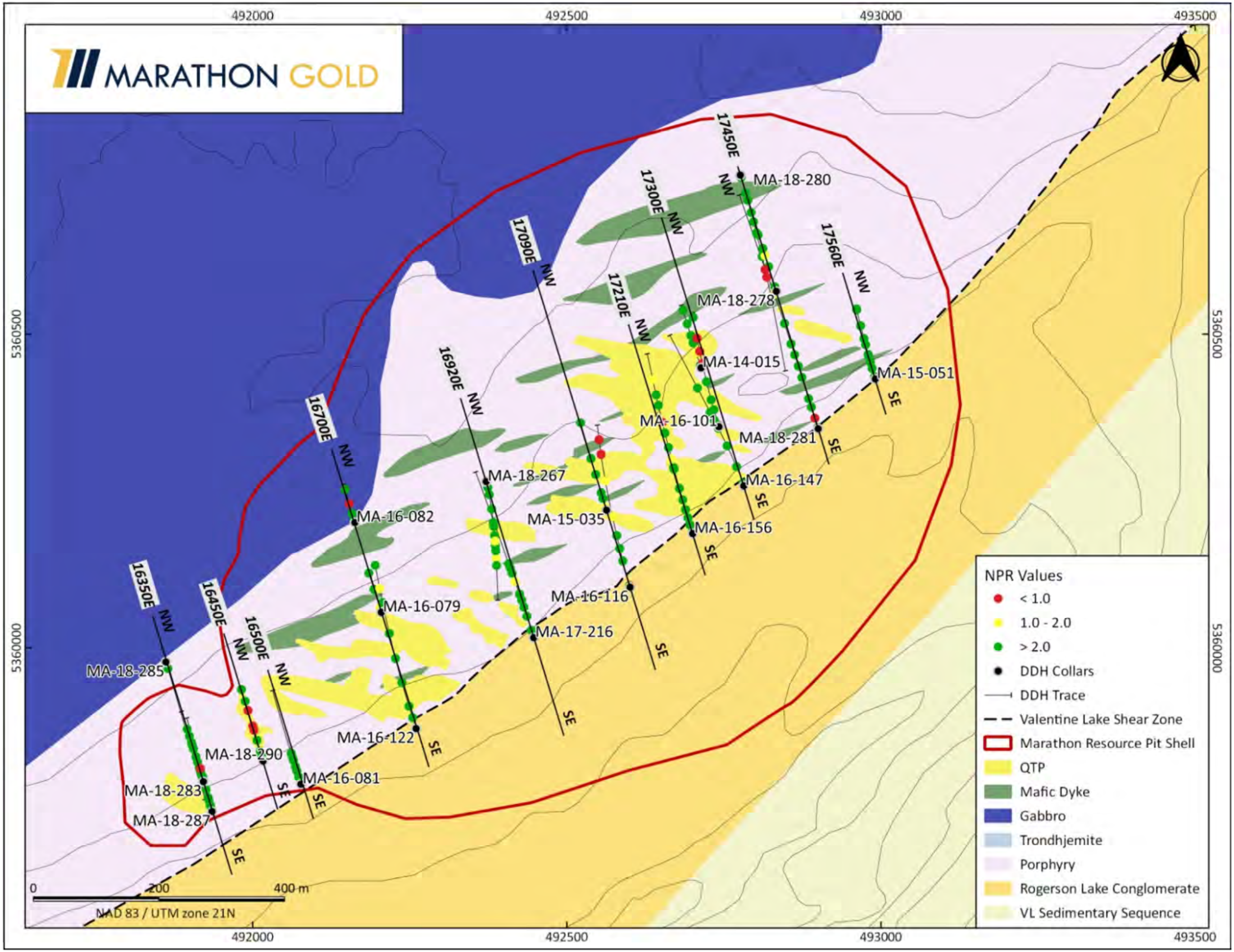
Figure IR-13.13 **Particle traces illustrating flow paths from Waste Rock Piles and LGO Stockpiles following closure with enhanced permeability fault**



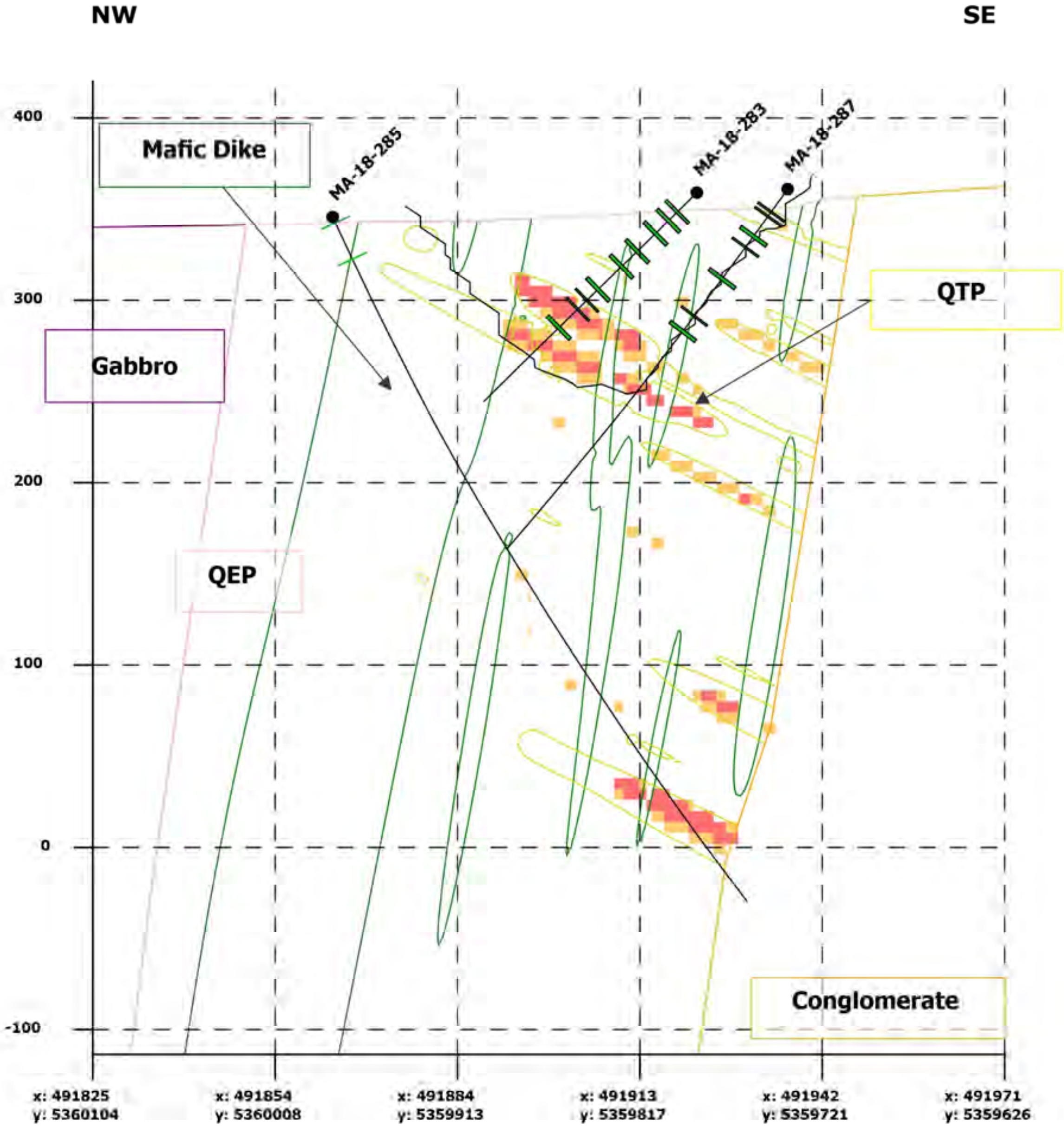
Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.

Figure IR-13.14 Particle traces illustrating flow paths from Waste Rock Piles and LGO Stockpiles following closure with reduced permeability fault

APPENDIX IR-18.A
IR-18 MAPS AND CROSS-SECTIONS


MARATHON GOLD
492000
492500
493000
493500
5360500
5360000
16350E
16450E
16500E
16700E
16920E
17090E
17210E
17300E
17450E
17560E
NW
SE
MA-18-280
MA-18-278
MA-14-015
MA-15-051
MA-16-101
MA-18-281
MA-16-147
MA-16-156
MA-18-267
MA-15-035
MA-16-082
MA-16-116
MA-16-079
MA-17-216
MA-18-285
MA-16-122
MA-18-290
MA-16-081
MA-18-283
MA-18-287
0
200
400 m
NAD 83 / UTM zone 21N
NPR Values
< 1.0
1.0 - 2.0
> 2.0
DDH Collars
DDH Trace
Valentine Lake Shear Zone
Marathon Resource Pit Shell
QTP
Mafic Dyke
Gabbro
Trondhjemite
Porphyry
Rogerson Lake Conglomerate
VL Sedimentary Sequence

16350E



Location

NW:	491825, 5360104
SE:	491972, 5359625

NPR Vaues of Samples

- 🟨 NPR 1 - 2
- 🟥 NPR < 1
- 🟩 NPR > 2

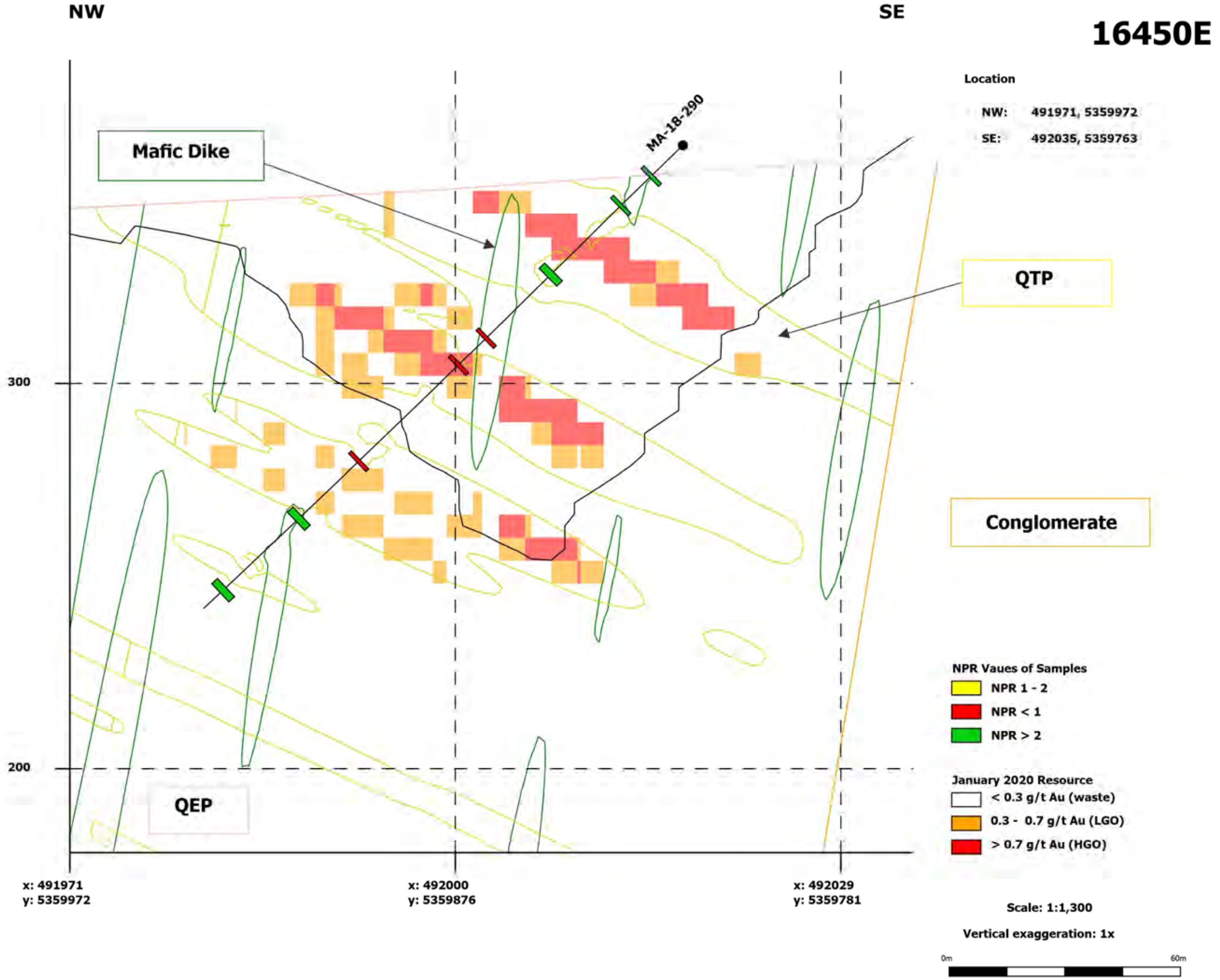
January 2020 Resource

- ☐ < 0.3 g/t Au (waste)
- 🟧 0.3 - 0.7 g/t Au (LGO)
- 🟥 > 0.7 g/t Au (HGO)

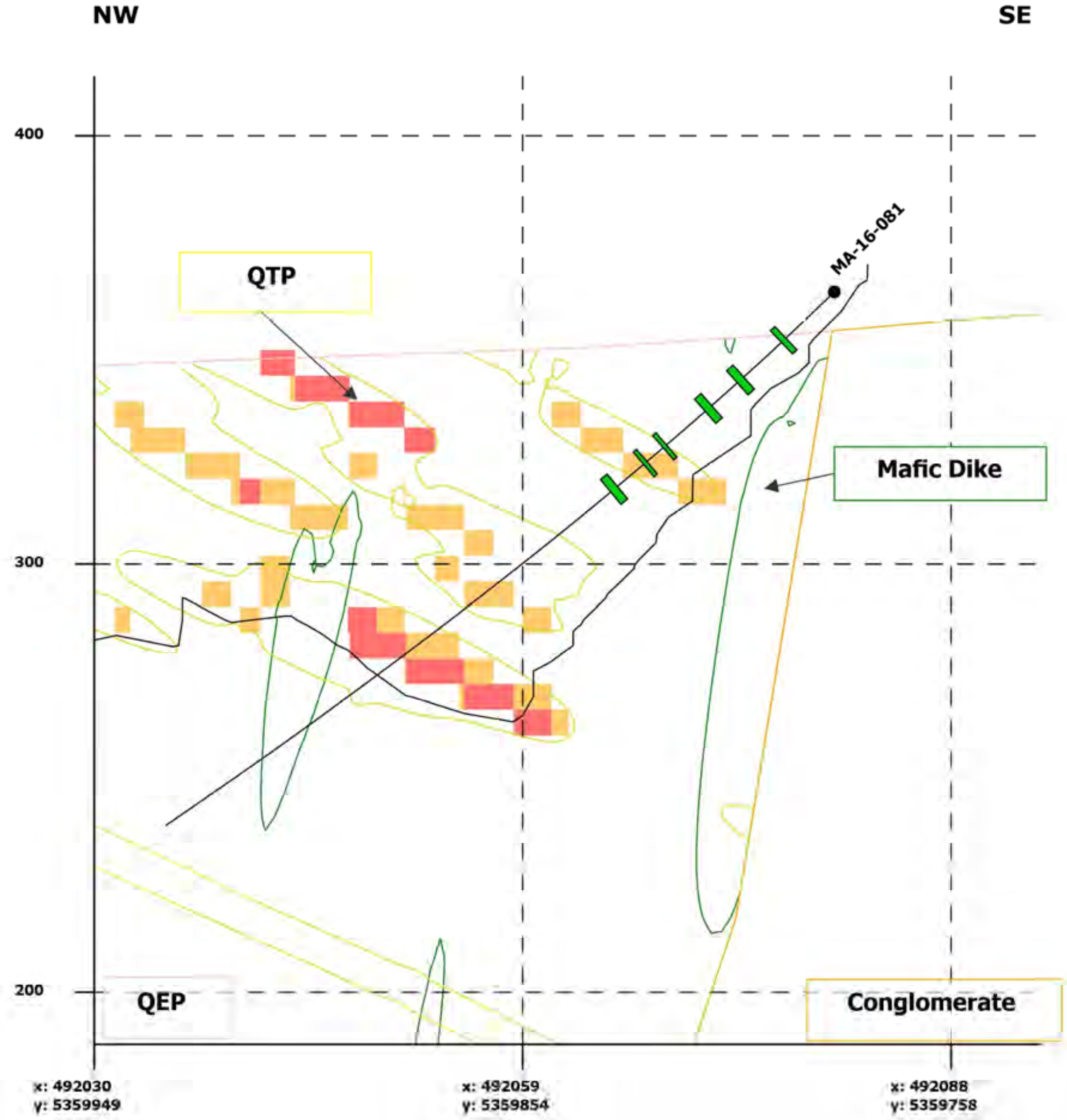
Scale: 1:3,500

Vertical exaggeration: 1x

0m 200m


NW
SE
16450E
Location
NW: 491971, 5359972
SE: 492035, 5359763
MA-18-290
Mafic Dike
QTP
Conglomerate
QEP
300
200
x: 491971
y: 5359972
x: 492000
y: 5359876
x: 492029
y: 5359781
NPR Vaues of Samples
🟨 NPR 1 - 2
🟥 NPR < 1
🟩 NPR > 2
January 2020 Resource
☐ < 0.3 g/t Au (waste)
🟧 0.3 - 0.7 g/t Au (LGO)
🟥 > 0.7 g/t Au (HGO)
Scale: 1:1,300
Vertical exaggeration: 1x
0m
60m

16500E



Location

NW:	492030, 5359949
SE:	492095, 5359738

NPR Vaues of Samples

- 🟨 NPR 1 - 2
- 🟥 NPR < 1
- 🟩 NPR > 2

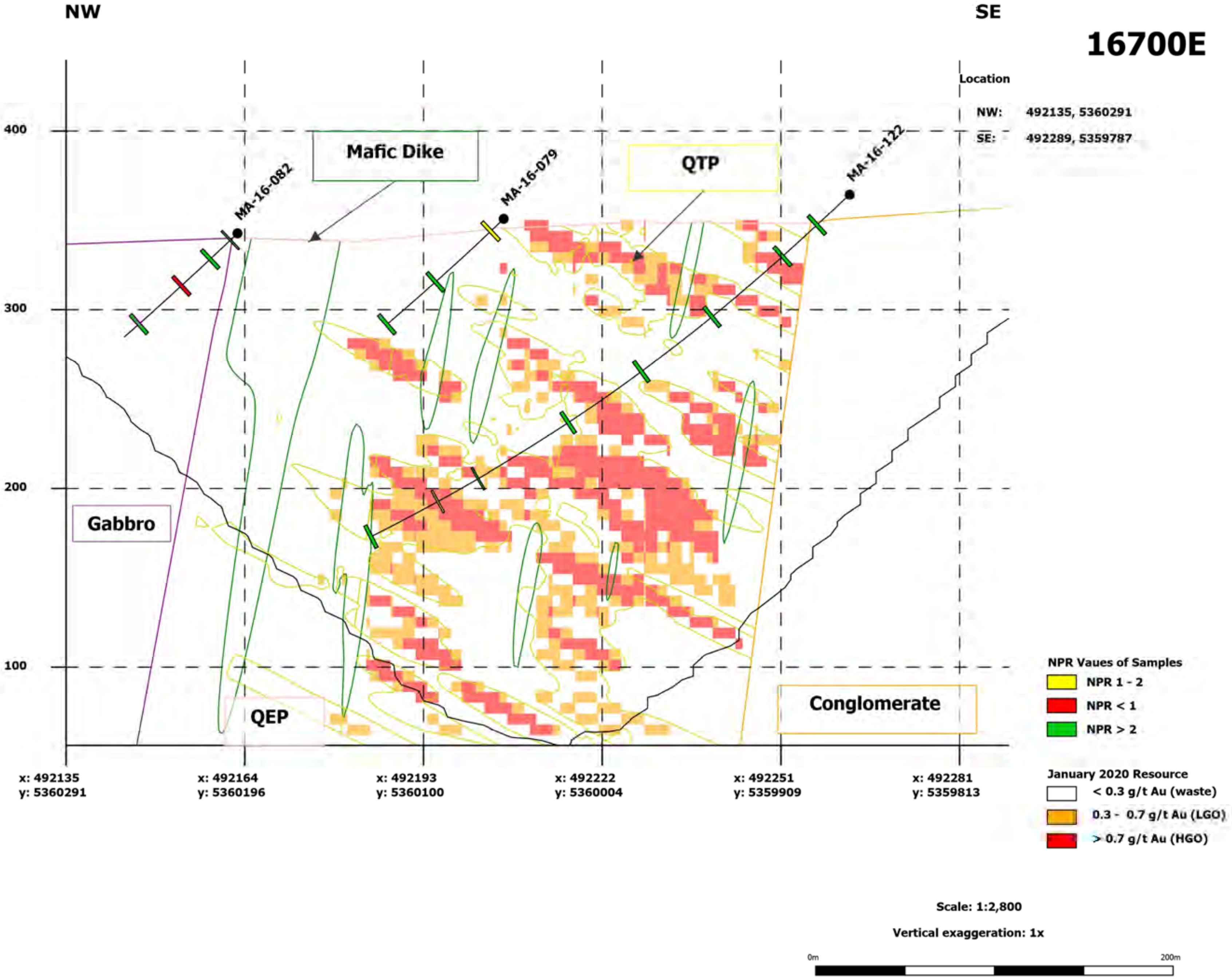
January 2020 Resource

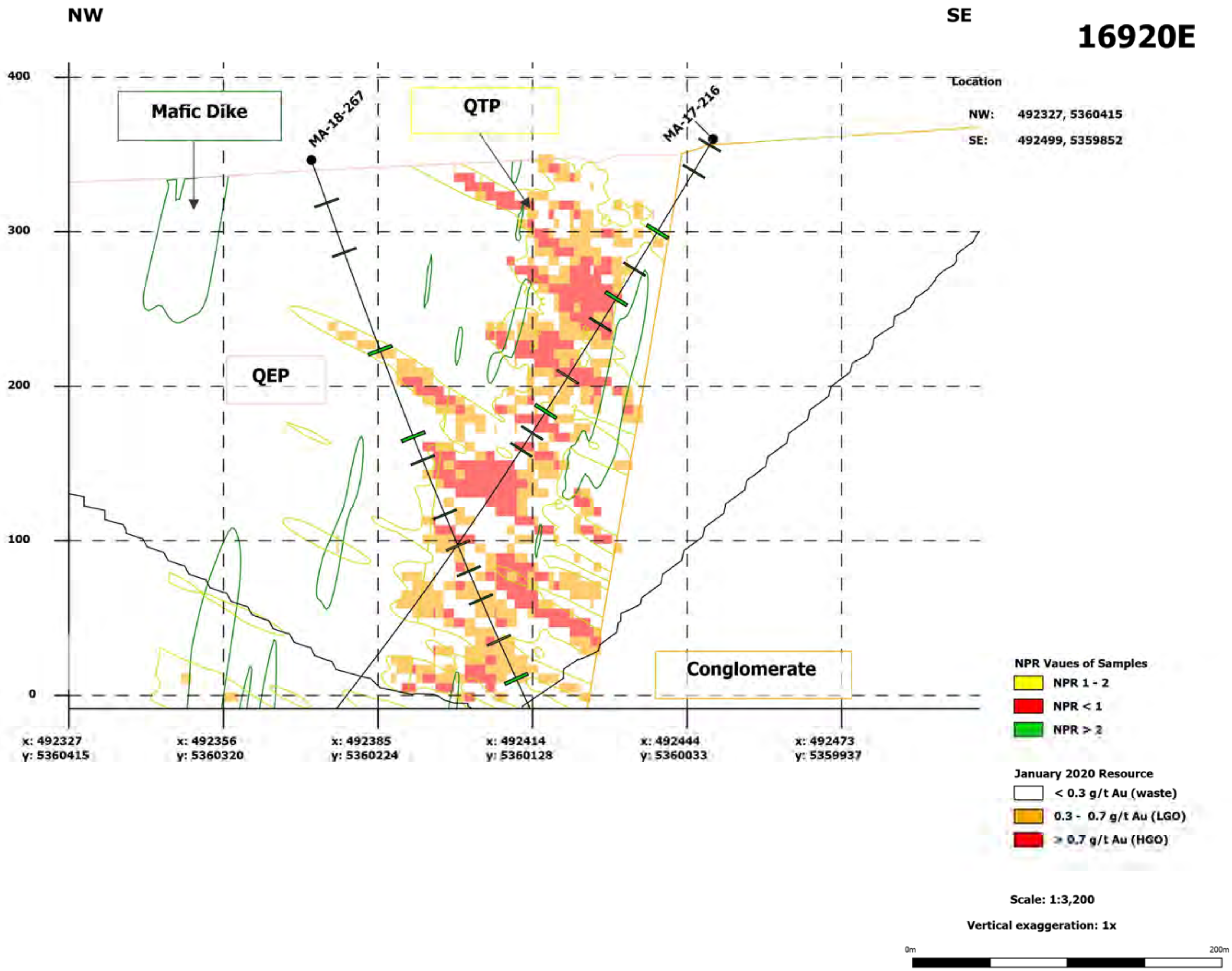
- ☐ < 0.3 g/t Au (waste)
- 🟧 0.3 - 0.7 g/t Au (LGO)
- 🟥 > 0.7 g/t Au (HGO)

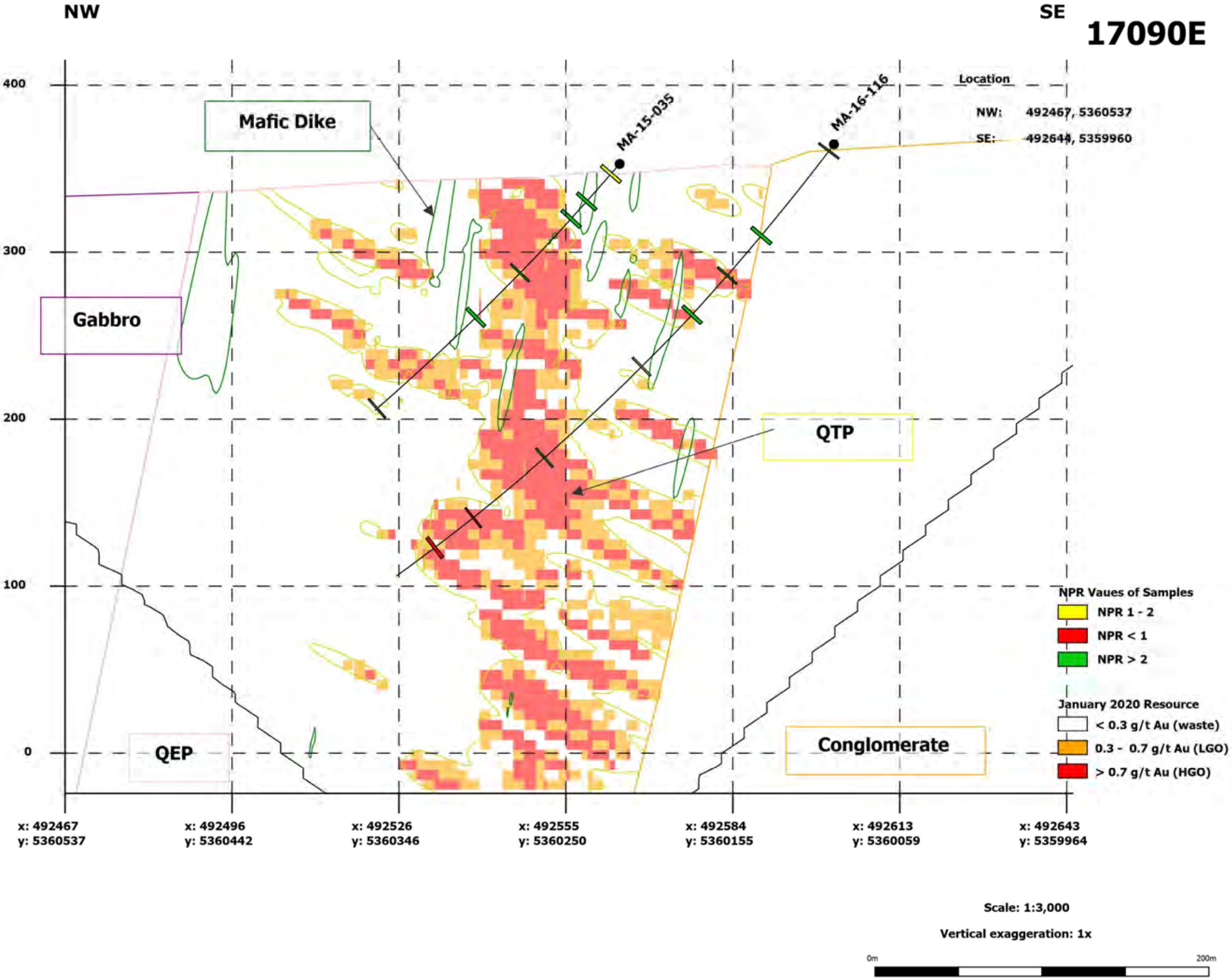
Scale: 1:1,500

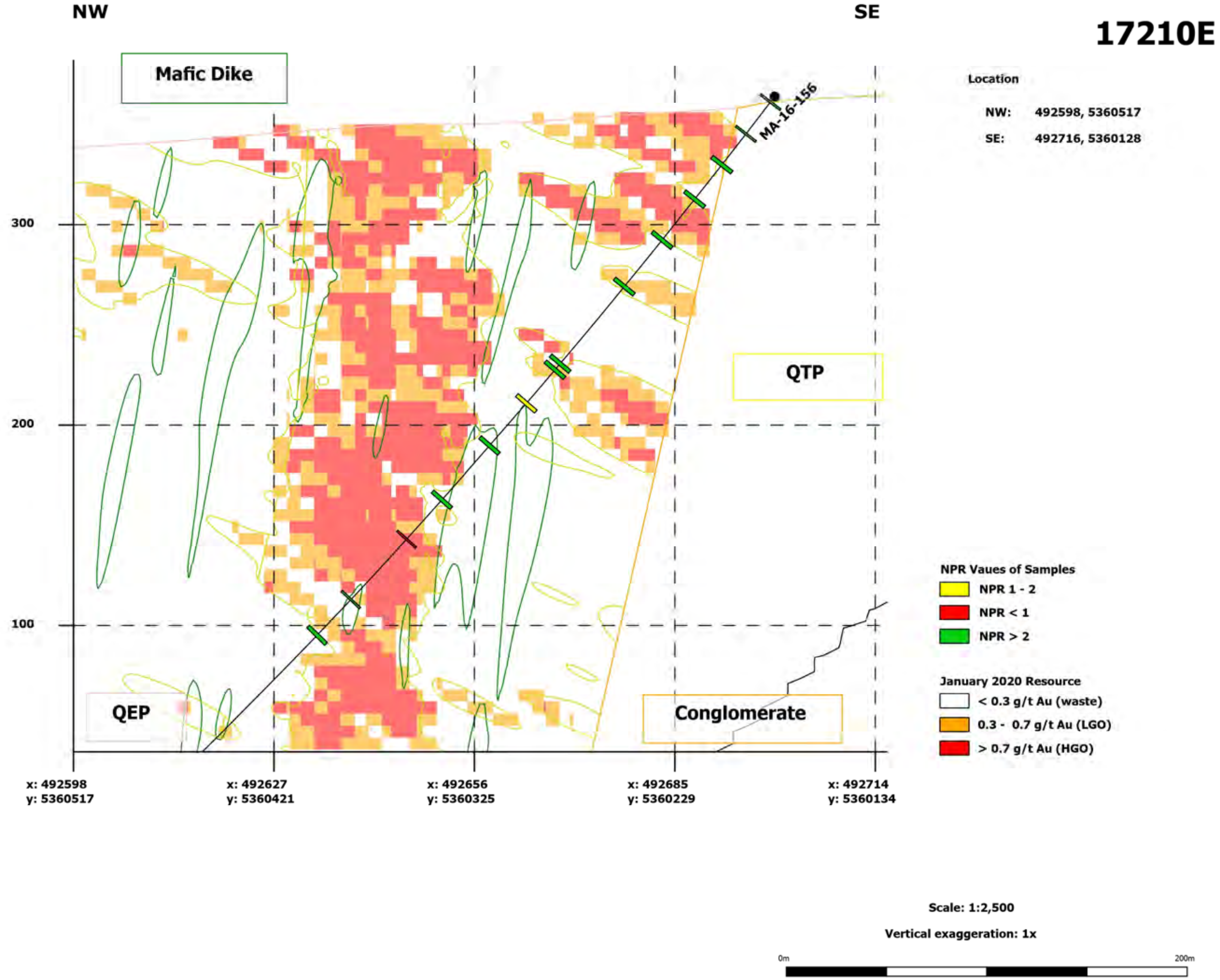
Vertical exaggeration: 1x

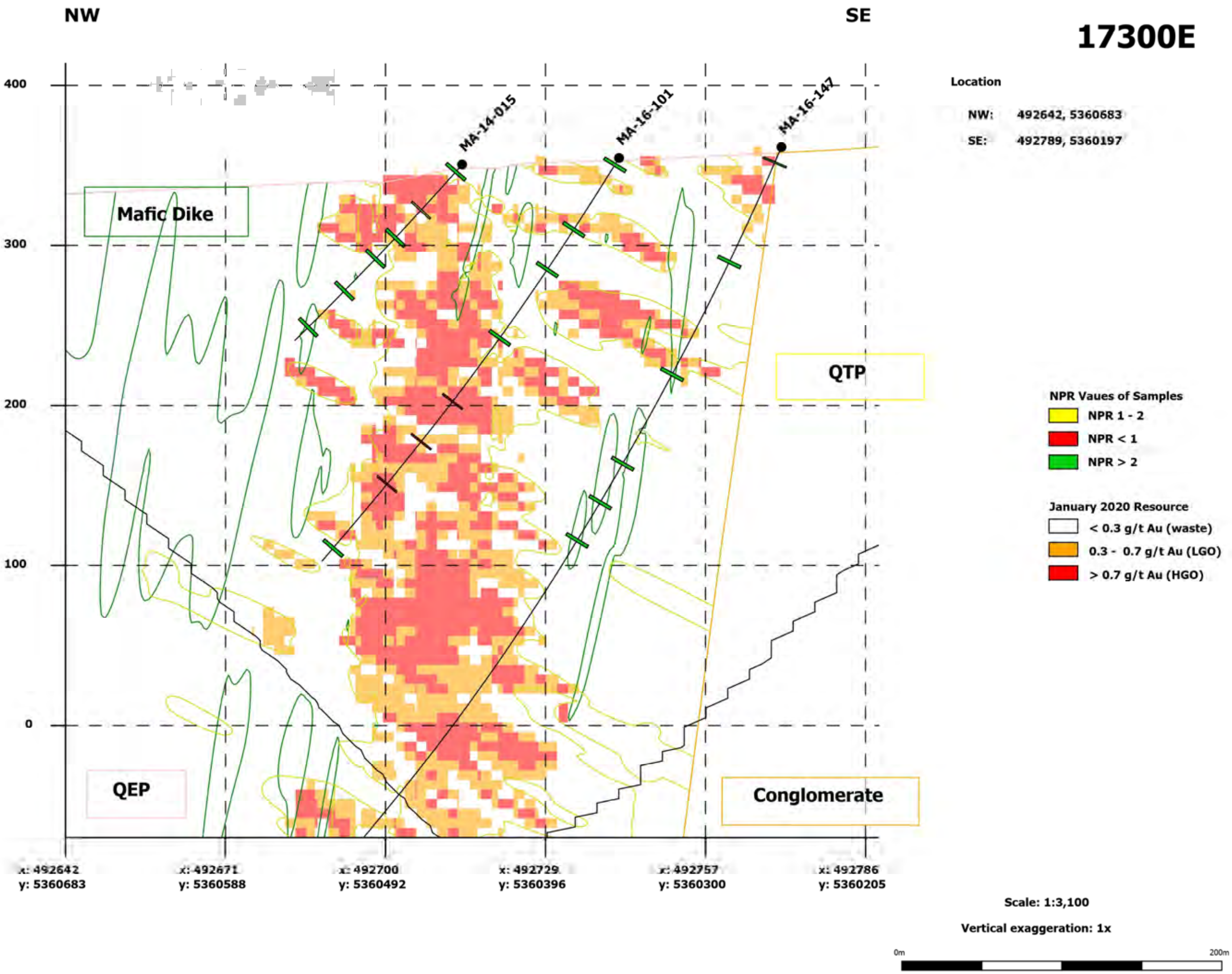
0m 80m

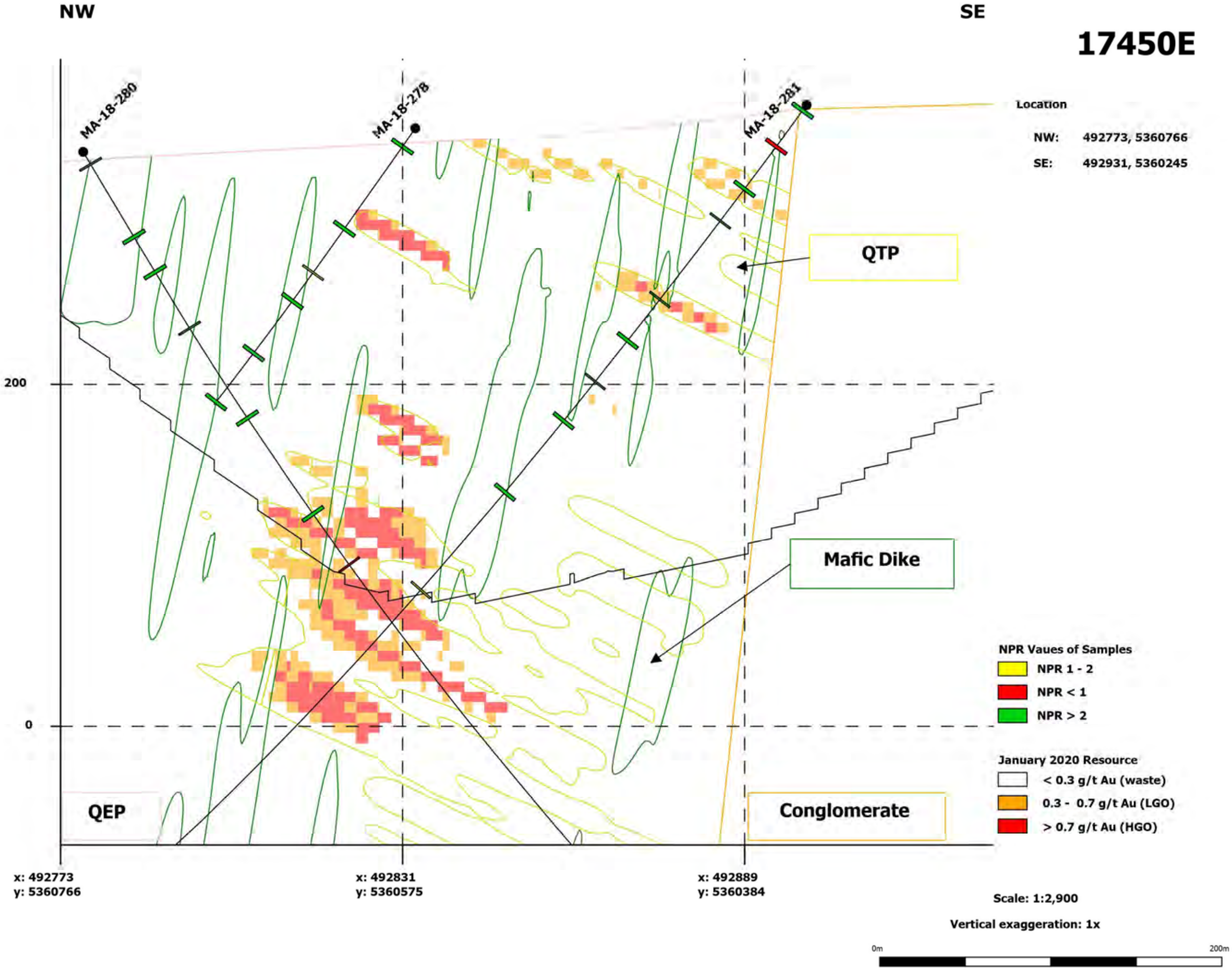

NW
SE
16700E
Location
NW: 492135, 5360291
SE: 492289, 5359787
400
300
200
100
Mafic Dike
QTP
MA-16-082
MA-16-079
MA-16-122
Gabbro
QEP
Conglomerate
x: 492135
y: 5360291
x: 492164
y: 5360196
x: 492193
y: 5360100
x: 492222
y: 5360004
x: 492251
y: 5359909
x: 492281
y: 5359813
NPR Vaues of Samples
🟨 NPR 1 - 2
🟥 NPR < 1
🟩 NPR > 2
January 2020 Resource
☐ < 0.3 g/t Au (waste)
🟧 0.3 - 0.7 g/t Au (LGO)
🟥 > 0.7 g/t Au (HGO)
Scale: 1:2,800
Vertical exaggeration: 1x
0m
200m

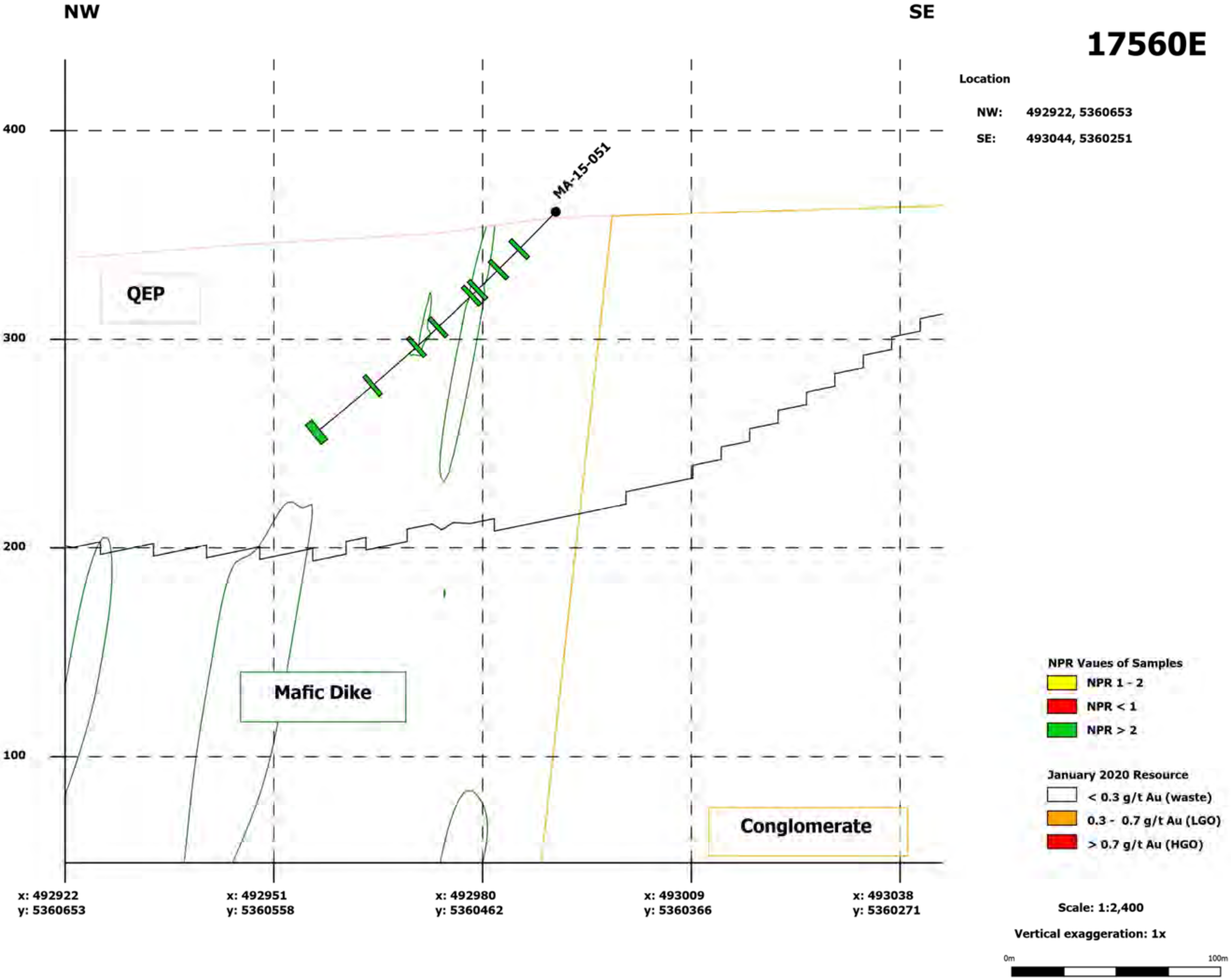

NW
SE
16920E
400
300
200
100
0
Location
NW: 492327, 5360415
SE: 492499, 5359852
Mafic Dike
MA-18-267
QTP
MA-17-216
QEP
Conglomerate
x: 492327
y: 5360415
x: 492356
y: 5360320
x: 492385
y: 5360224
x: 492414
y: 5360128
x: 492444
y: 5360033
x: 492473
y: 5359937
NPR Vaues of Samples
NPR 1 - 2
NPR < 1
NPR > 2
January 2020 Resource
< 0.3 g/t Au (waste)
0.3 - 0.7 g/t Au (LGO)
> 0.7 g/t Au (HGO)
Scale: 1:3,200
Vertical exaggeration: 1x
0m
200m

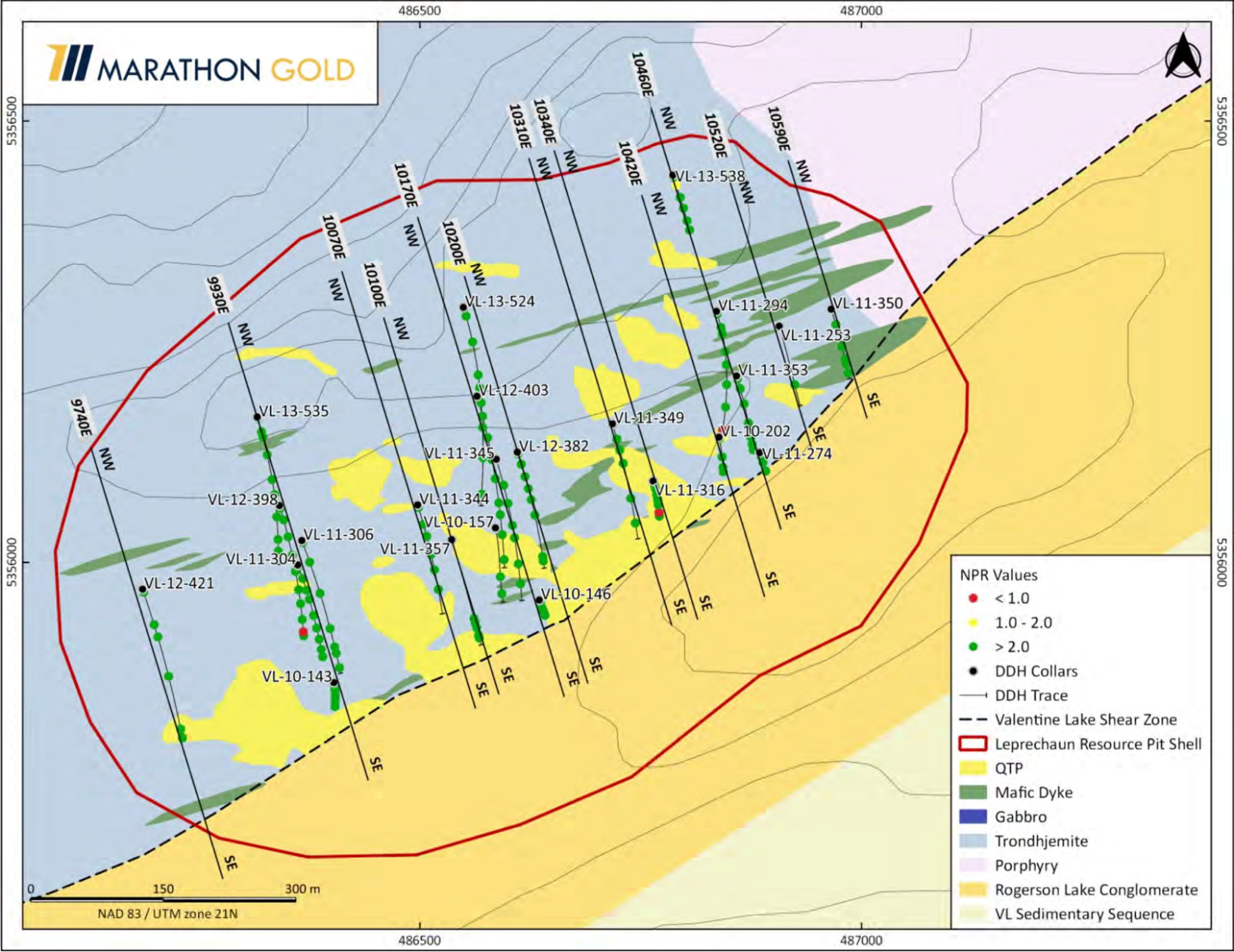

NW
SE
17090E
Location
NW: 492467, 5360537
SE: 492644, 5359960
400
300
200
100
0
Mafic Dike
Gabbro
QTP
QEP
Conglomerate
MA-15-035
MA-16-116
x: 492467
y: 5360537
x: 492496
y: 5360442
x: 492526
y: 5360346
x: 492555
y: 5360250
x: 492584
y: 5360155
x: 492613
y: 5360059
x: 492643
y: 5359964
NPR Vaues of Samples
NPR 1 - 2
NPR < 1
NPR > 2
January 2020 Resource
< 0.3 g/t Au (waste)
0.3 - 0.7 g/t Au (LGO)
> 0.7 g/t Au (HGO)
Scale: 1:3,000
Vertical exaggeration: 1x
0m
200m

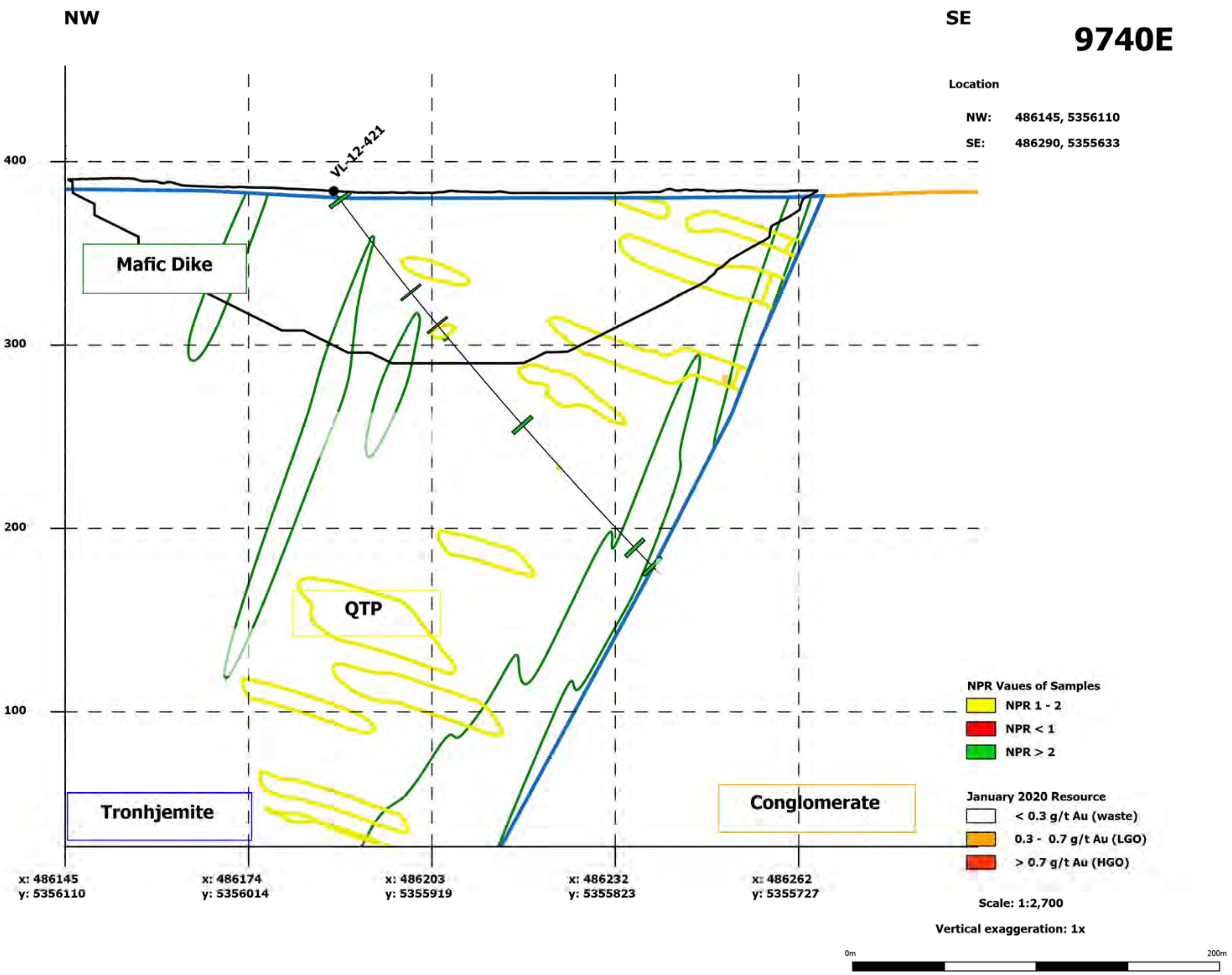

NW
SE
17210E
Mafic Dike
MA-16-156
QTP
QEP
Conglomerate
300
200
100
x: 492598
y: 5360517
x: 492627
y: 5360421
x: 492656
y: 5360325
x: 492685
y: 5360229
x: 492714
y: 5360134
Location
NW: 492598, 5360517
SE: 492716, 5360128
NPR Vaues of Samples
NPR 1 - 2
NPR < 1
NPR > 2
January 2020 Resource
< 0.3 g/t Au (waste)
0.3 - 0.7 g/t Au (LGO)
> 0.7 g/t Au (HGO)
Scale: 1:2,500
Vertical exaggeration: 1x
0m
200m

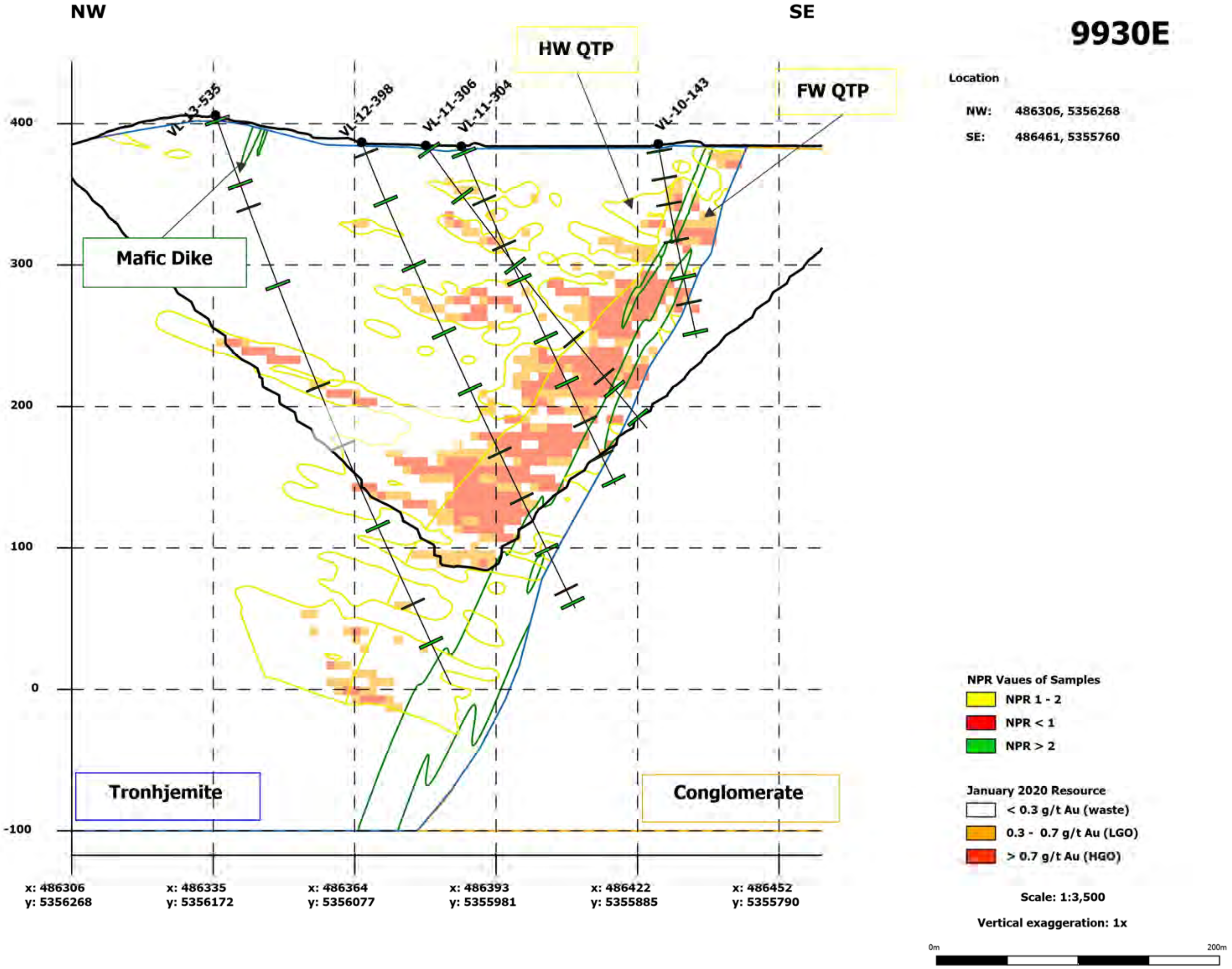
NW
SE
17300E
Location
NW: 492642, 5360683
SE: 492789, 5360197
400
300
200
100
0
MA-14-015
MA-16-101
MA-16-147
Mafic Dike
QTP
QEP
Conglomerate
NPR Vaues of Samples
🟨 NPR 1 - 2
🟥 NPR < 1
🟩 NPR > 2
January 2020 Resource
☐ < 0.3 g/t Au (waste)
🟧 0.3 - 0.7 g/t Au (LGO)
🟥 > 0.7 g/t Au (HGO)
x: 492642
y: 5360683
x: 492671
y: 5360588
x: 492700
y: 5360492
x: 492729
y: 5360396
x: 492757
y: 5360300
x: 492786
y: 5360205
Scale: 1:3,100
Vertical exaggeration: 1x
0m
200m


NW
SE
17450E
MA-18-280
MA-18-278
MA-18-281
Location
NW: 492773, 5360766
SE: 492931, 5360245
QTP
200
Mafic Dike
0
QEP
Conglomerate
NPR Vaues of Samples
NPR 1 - 2
NPR < 1
NPR > 2
January 2020 Resource
< 0.3 g/t Au (waste)
0.3 - 0.7 g/t Au (LGO)
> 0.7 g/t Au (HGO)
x: 492773
y: 5360766
x: 492831
y: 5360575
x: 492889
y: 5360384
Scale: 1:2,900
Vertical exaggeration: 1x
0m
200m


NW
SE
17560E
Location
NW: 492922, 5360653
SE: 493044, 5360251
400
300
200
100
MA-15-051
QEP
Mafic Dike
Conglomerate
x: 492922
y: 5360653
x: 492951
y: 5360558
x: 492980
y: 5360462
x: 493009
y: 5360366
x: 493038
y: 5360271
NPR Vaues of Samples
🟨 NPR 1 - 2
🟥 NPR < 1
🟩 NPR > 2
January 2020 Resource
☐ < 0.3 g/t Au (waste)
🟧 0.3 - 0.7 g/t Au (LGO)
🟥 > 0.7 g/t Au (HGO)
Scale: 1:2,400
Vertical exaggeration: 1x
0m
100m


MARATHON GOLD
486500
487000
5356500
5356000
9740E
9930E
10070E
10100E
10170E
10200E
10310E
10340E
10420E
10460E
10520E
10590E
NW
SE
VL-13-538
VL-13-524
VL-11-294
VL-11-350
VL-11-253
VL-11-353
VL-12-403
VL-13-535
VL-11-349
VL-10-202
VL-11-345
VL-12-382
VL-11-274
VL-11-316
VL-12-398
VL-11-344
VL-10-157
VL-11-306
VL-11-357
VL-11-304
VL-12-421
VL-10-146
VL-10-143
0
150
300 m
NAD 83 / UTM zone 21N
NPR Values
< 1.0
1.0 - 2.0
> 2.0
DDH Collars
DDH Trace
Valentine Lake Shear Zone
Leprechaun Resource Pit Shell
QTP
Mafic Dyke
Gabbro
Trondhjemite
Porphyry
Rogerson Lake Conglomerate
VL Sedimentary Sequence

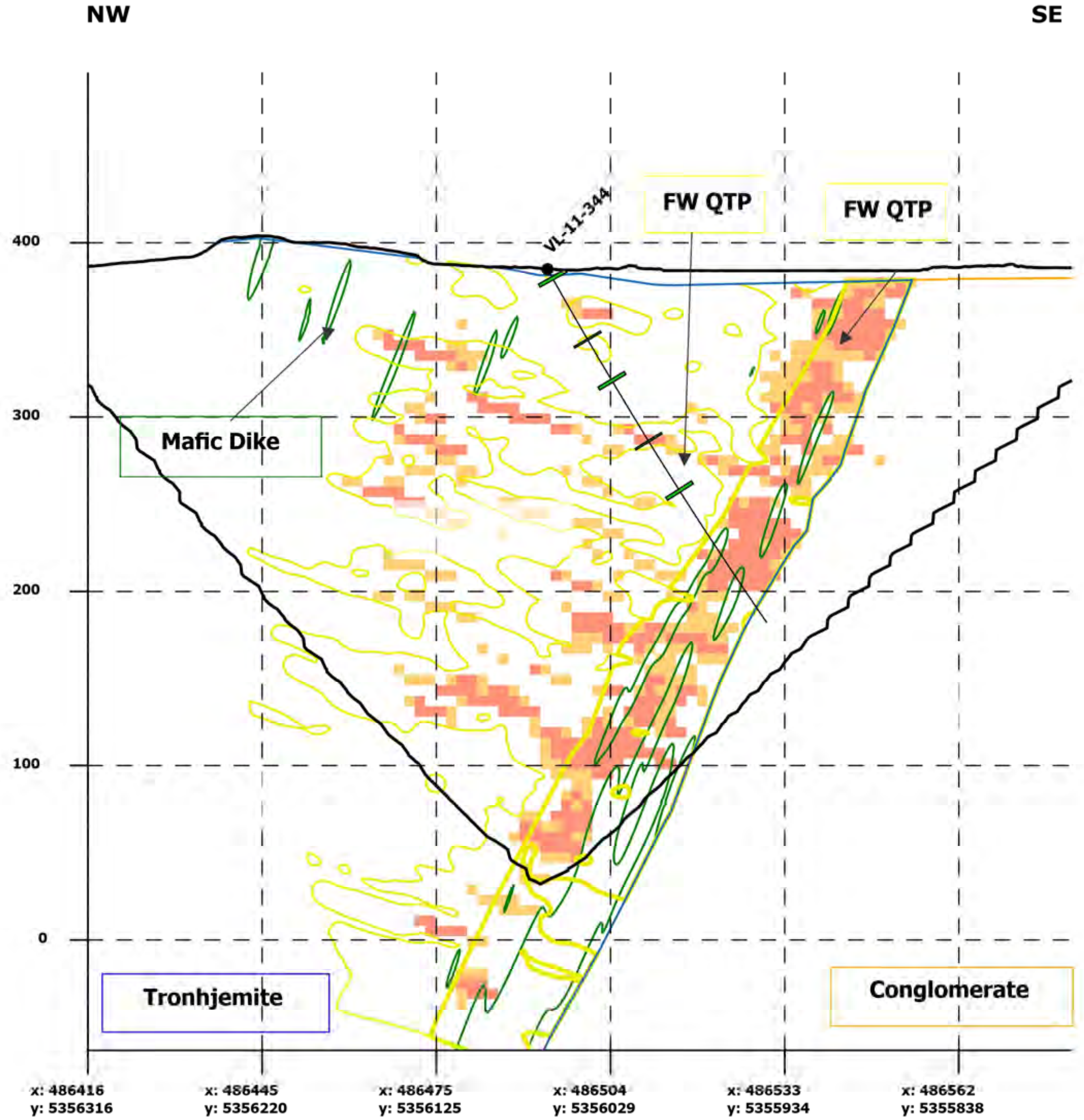

NW
SE
9740E
Location
NW: 486145, 5356110
SE: 486290, 5355633
400
300
200
100
VL-12-421
Mafic Dike
QTP
Tronhjemite
Conglomerate
x: 486145
y: 5356110
x: 486174
y: 5356014
x: 486203
y: 5355919
x: 486232
y: 5355823
x: 486262
y: 5355727
NPR Vaues of Samples
🟨 NPR 1 - 2
🟥 NPR < 1
🟩 NPR > 2
January 2020 Resource
☐ < 0.3 g/t Au (waste)
🟧 0.3 - 0.7 g/t Au (LGO)
🟥 > 0.7 g/t Au (HGO)
Scale: 1:2,700
Vertical exaggeration: 1x
0m
200m


NW
SE
9930E
HW QTP
FW QTP
Location
NW: 486306, 5356268
SE: 486461, 5355760
VL-13-535
VL-12-398
VL-11-306
VL-11-304
VL-10-143
400
300
200
100
0
-100
Mafic Dike
Tronhjemite
Conglomerate
x: 486306
y: 5356268
x: 486335
y: 5356172
x: 486364
y: 5356077
x: 486393
y: 5355981
x: 486422
y: 5355885
x: 486452
y: 5355790
NPR Vaues of Samples
🟨 NPR 1 - 2
🟥 NPR < 1
🟩 NPR > 2
January 2020 Resource
☐ < 0.3 g/t Au (waste)
🟧 0.3 - 0.7 g/t Au (LGO)
🟥 > 0.7 g/t Au (HGO)
Scale: 1:3,500
Vertical exaggeration: 1x
0m
200m

10070E

Location

NW:	486416, 5356316
SE:	486581, 5355776



NPR Vaues of Samples

- 🟨 NPR 1 - 2
- 🟥 NPR < 1
- 🟩 NPR > 2

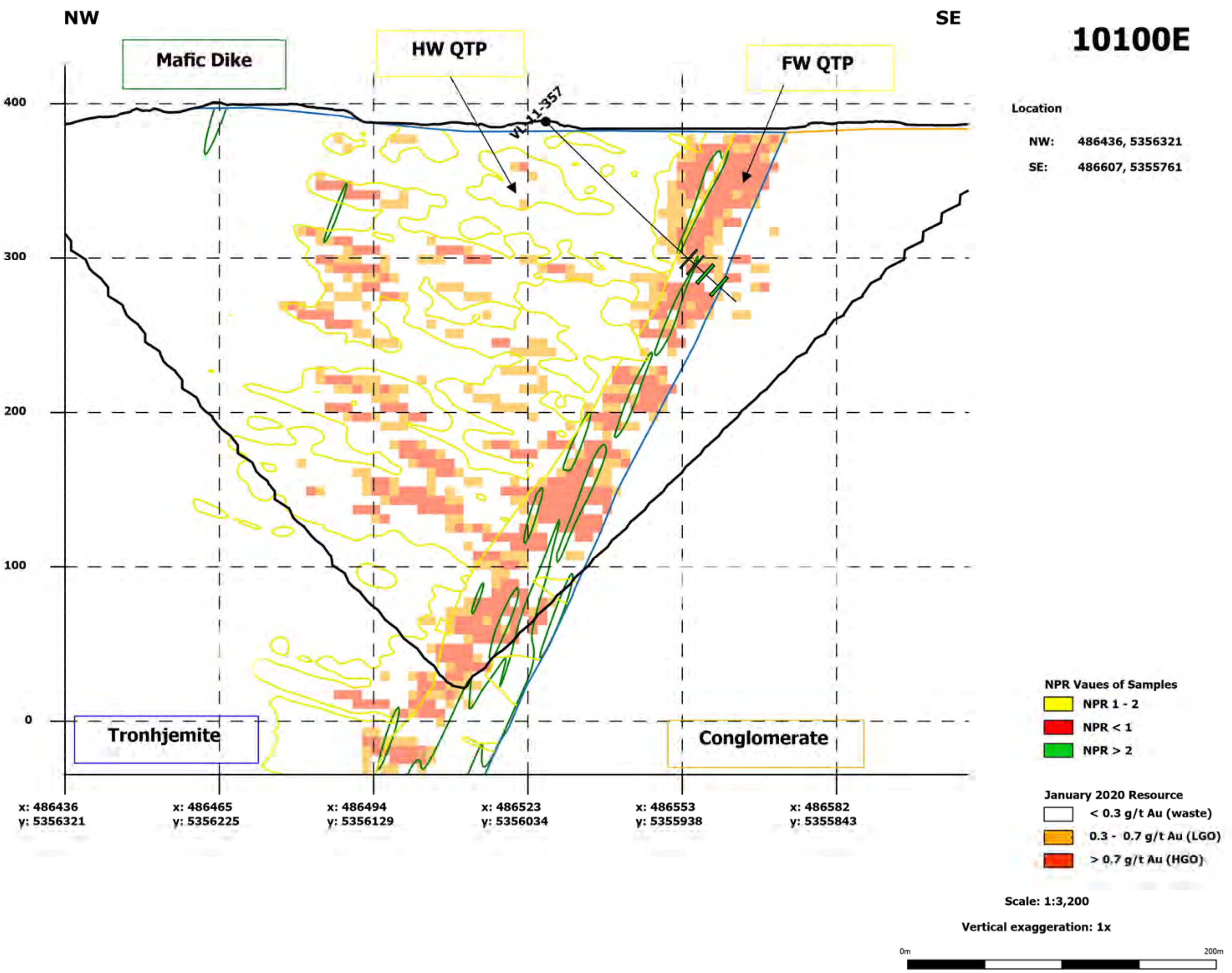
January 2020 Resource

- ☐ < 0.3 g/t Au (waste)
- 🟧 0.3 - 0.7 g/t Au (LGO)
- 🟥 > 0.7 g/t Au (HGO)

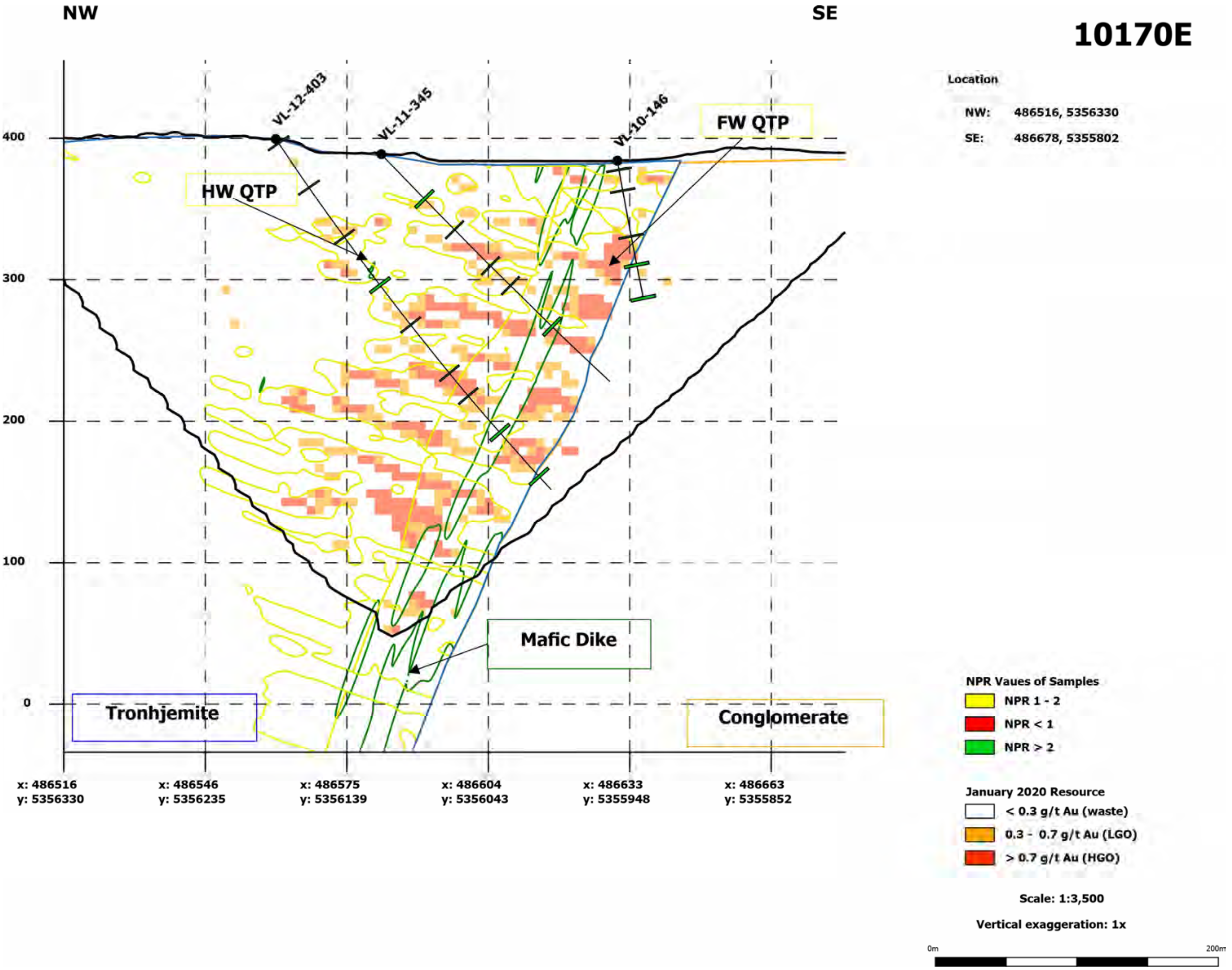
Scale: 1:3,500

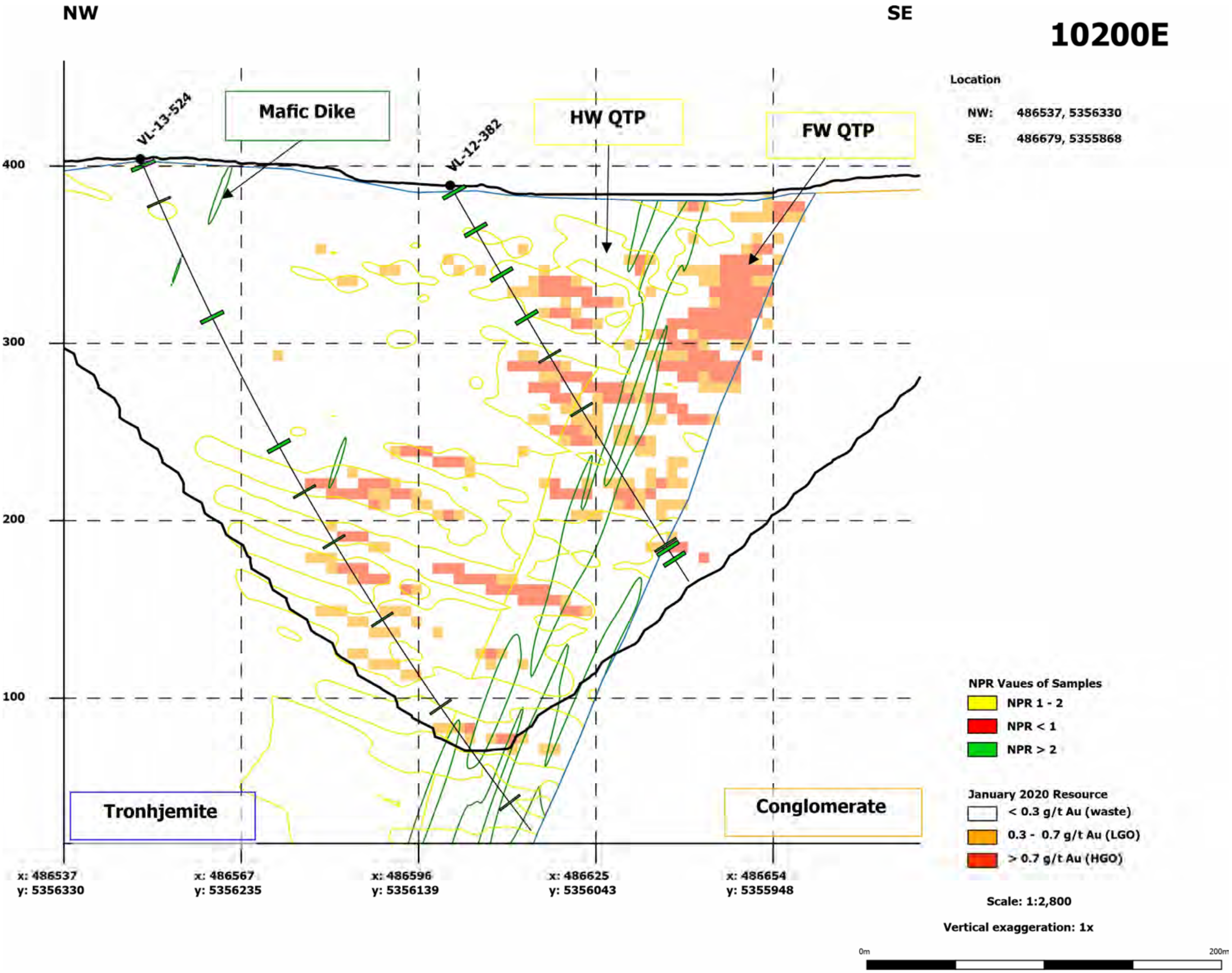
Vertical exaggeration: 1x

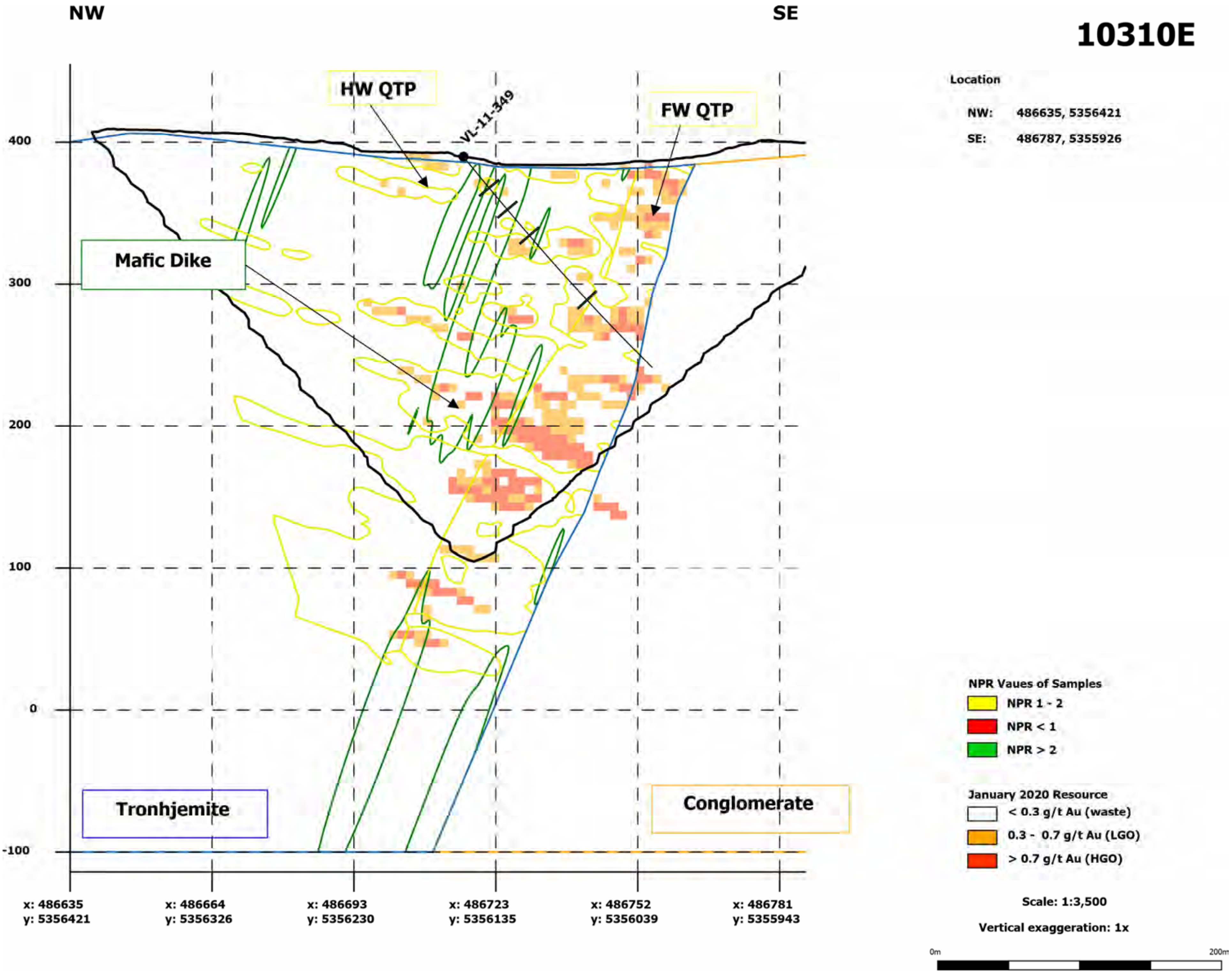
0m 200m

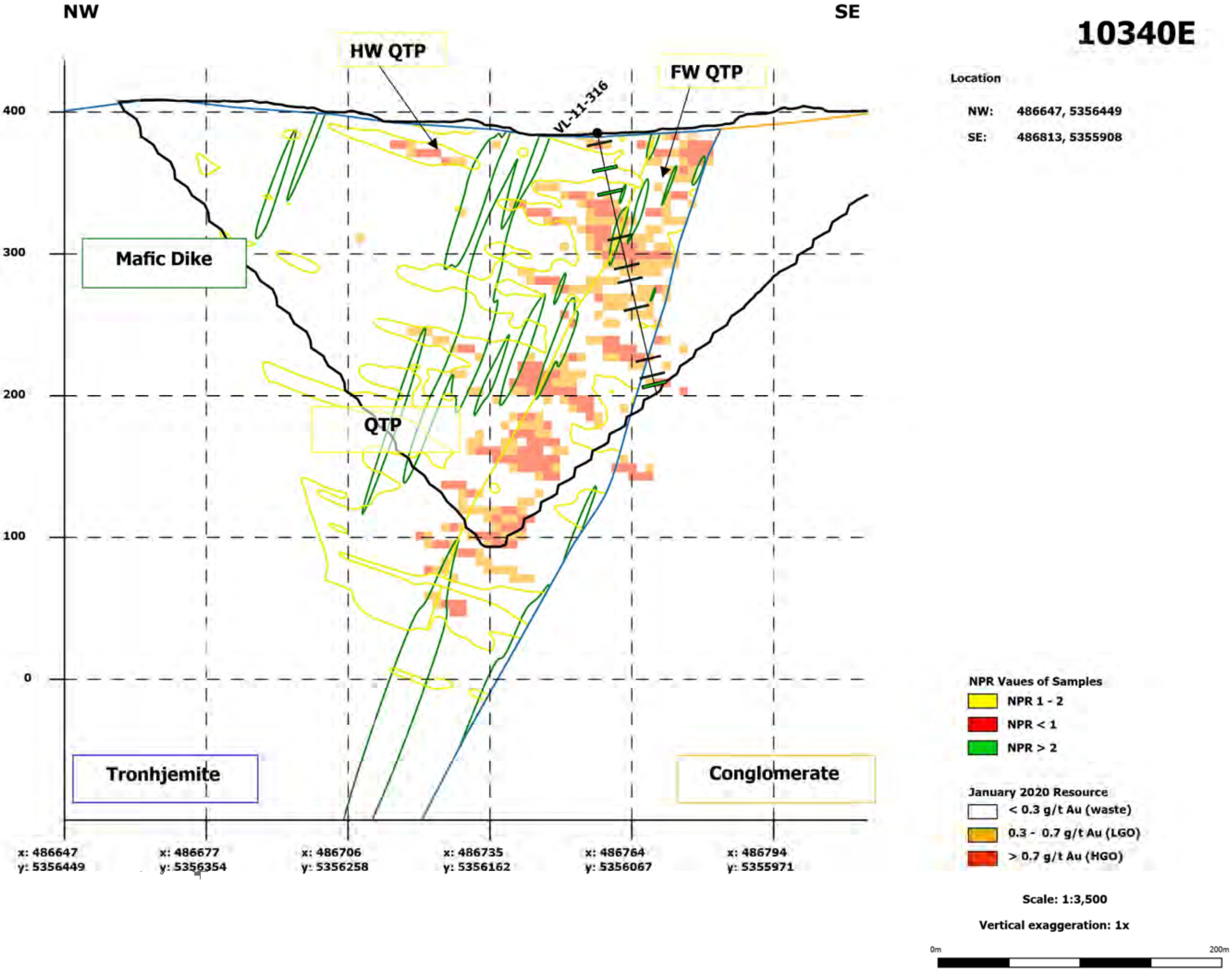

NW
SE
10100E
Mafic Dike
HW QTP
FW QTP
VL-11-357
Location
NW: 486436, 5356321
SE: 486607, 5355761
400
300
200
100
0
Tronhjemite
Conglomerate
x: 486436
y: 5356321
x: 486465
y: 5356225
x: 486494
y: 5356129
x: 486523
y: 5356034
x: 486553
y: 5355938
x: 486582
y: 5355843
NPR Vaues of Samples
🟨 NPR 1 - 2
🟥 NPR < 1
🟩 NPR > 2
January 2020 Resource
☐ < 0.3 g/t Au (waste)
🟧 0.3 - 0.7 g/t Au (LGO)
🟥 > 0.7 g/t Au (HGO)
Scale: 1:3,200
Vertical exaggeration: 1x
0m
200m

10170E

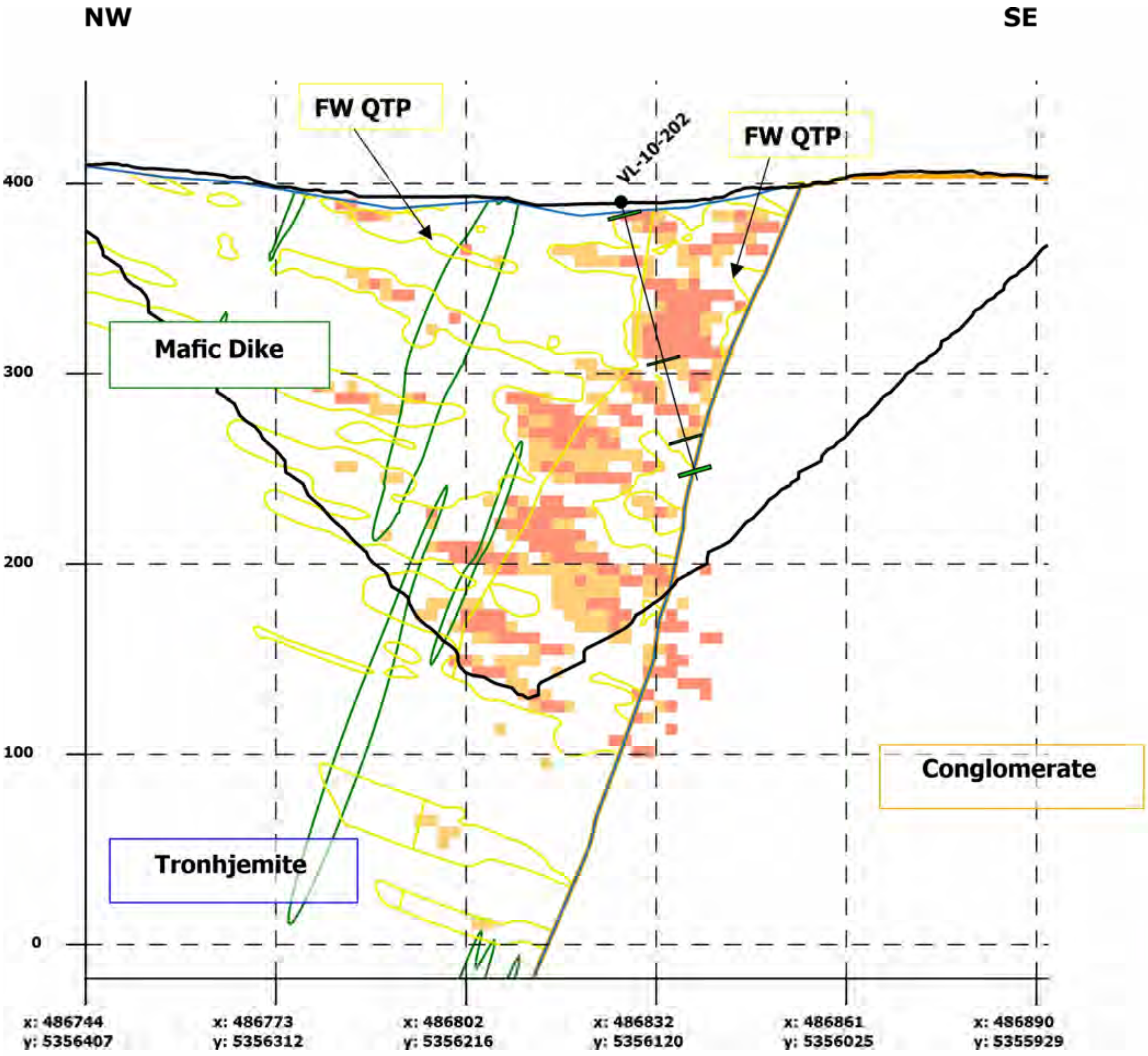

NW
SE
Location
NW: 486516, 5356330
SE: 486678, 5355802
400
300
200
100
0
VL-12-403
VL-11-345
VL-10-146
HW QTP
FW QTP
Mafic Dike
Tronhjemite
Conglomerate
x: 486516
y: 5356330
x: 486546
y: 5356235
x: 486575
y: 5356139
x: 486604
y: 5356043
x: 486633
y: 5355948
x: 486663
y: 5355852
NPR Vaues of Samples
NPR 1 - 2
NPR < 1
NPR > 2
January 2020 Resource
< 0.3 g/t Au (waste)
0.3 - 0.7 g/t Au (LGO)
> 0.7 g/t Au (HGO)
Scale: 1:3,500
Vertical exaggeration: 1x
0m
200m


NW
SE
10200E
Location
NW: 486537, 5356330
SE: 486679, 5355868
VL-13-524
Mafic Dike
VL-12-382
HW QTP
FW QTP
400
300
200
100
Tronhjemite
Conglomerate
x: 486537
y: 5356330
x: 486567
y: 5356235
x: 486596
y: 5356139
x: 486625
y: 5356043
x: 486654
y: 5355948
NPR Vaues of Samples
🟨 NPR 1 - 2
🟥 NPR < 1
🟩 NPR > 2
January 2020 Resource
☐ < 0.3 g/t Au (waste)
🟧 0.3 - 0.7 g/t Au (LGO)
🟥 > 0.7 g/t Au (HGO)
Scale: 1:2,800
Vertical exaggeration: 1x
0m
200m


NW
SE
10310E
Location
NW: 486635, 5356421
SE: 486787, 5355926
HW QTP
FW QTP
VL-11-349
Mafic Dike
Tronhjemite
Conglomerate
400
300
200
100
0
-100
x: 486635 y: 5356421
x: 486664 y: 5356326
x: 486693 y: 5356230
x: 486723 y: 5356135
x: 486752 y: 5356039
x: 486781 y: 5355943
NPR Vaues of Samples
🟨 NPR 1 - 2
🟥 NPR < 1
🟩 NPR > 2
January 2020 Resource
☐ < 0.3 g/t Au (waste)
🟧 0.3 - 0.7 g/t Au (LGO)
🟥 > 0.7 g/t Au (HGO)
Scale: 1:3,500
Vertical exaggeration: 1x
0m
200m


10340E
Location
NW: 486647, 5356449
SE: 486813, 5355908
NW
SE
HW QTP
FW QTP
VL-11-316
QTP
Mafic Dike
Tronhjemite
Conglomerate
400
300
200
100
0
x: 486647
y: 5356449
x: 486677
y: 5356354
x: 486706
y: 5356258
x: 486735
y: 5356162
x: 486764
y: 5356067
x: 486794
y: 5355971
NPR Vaues of Samples
NPR 1 - 2
NPR < 1
NPR > 2
January 2020 Resource
< 0.3 g/t Au (waste)
0.3 - 0.7 g/t Au (LGO)
> 0.7 g/t Au (HGO)
Scale: 1:3,500
Vertical exaggeration: 1x
0m
200m

10420E



Location

NW:	486744, 5356407
SE:	486892, 5355923

NPR Vaues of Samples

- 🟨 NPR 1 - 2
- 🟥 NPR < 1
- 🟩 NPR > 2

January 2020 Resource

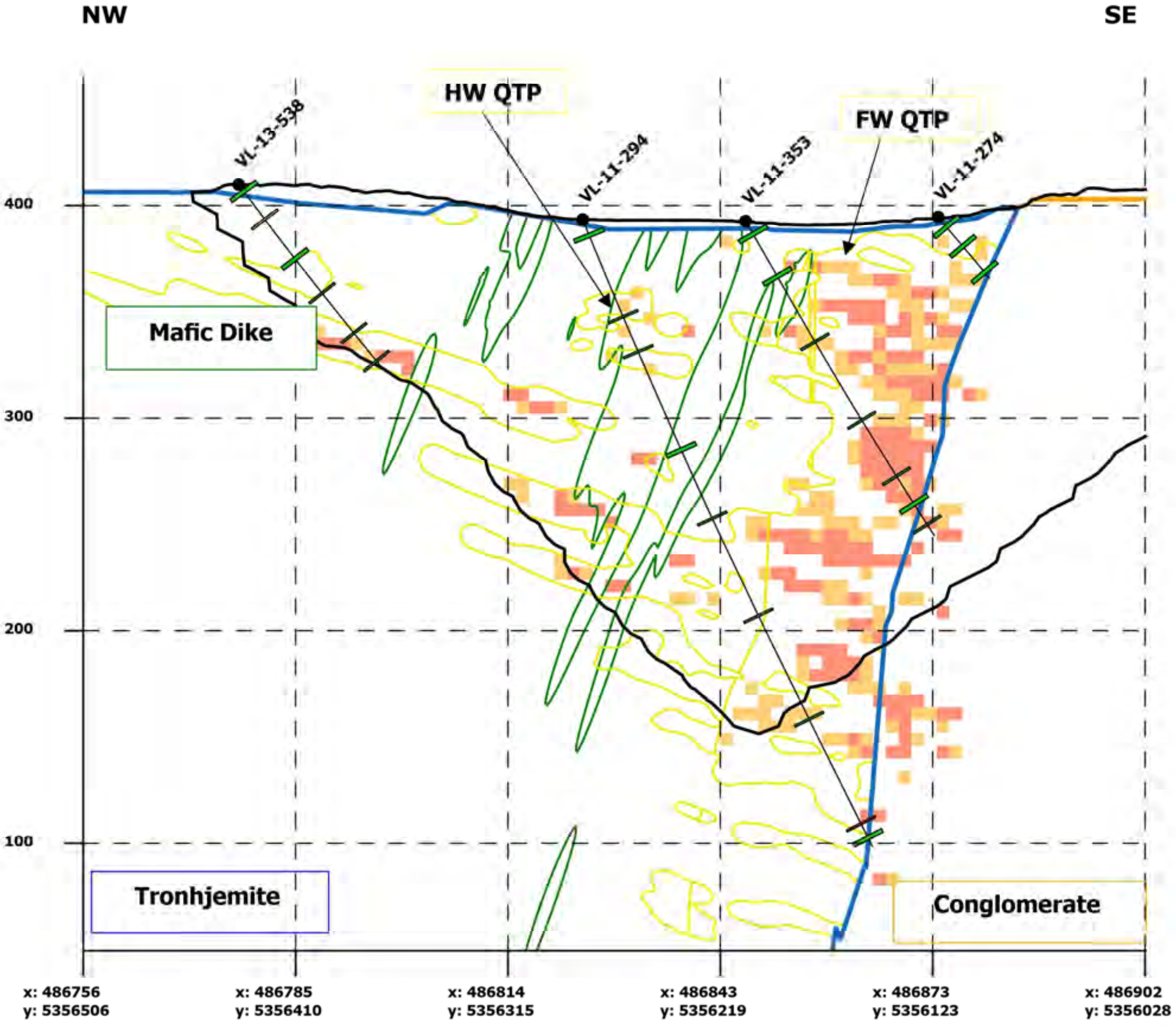
- ☐ < 0.3 g/t Au (waste)
- 🟧 0.3 - 0.7 g/t Au (LGO)
- 🟥 > 0.7 g/t Au (HGO)

Scale: 1:3,500

Vertical exaggeration: 1x

0m 200m

10460E



Location

NW:	486756, 5356506
SE:	486902, 5356027

NPR Vaues of Samples

🟨 NPR 1 - 2

🟥 NPR < 1

🟩 NPR > 2

January 2020 Resource

☐ < 0.3 g/t Au (waste)

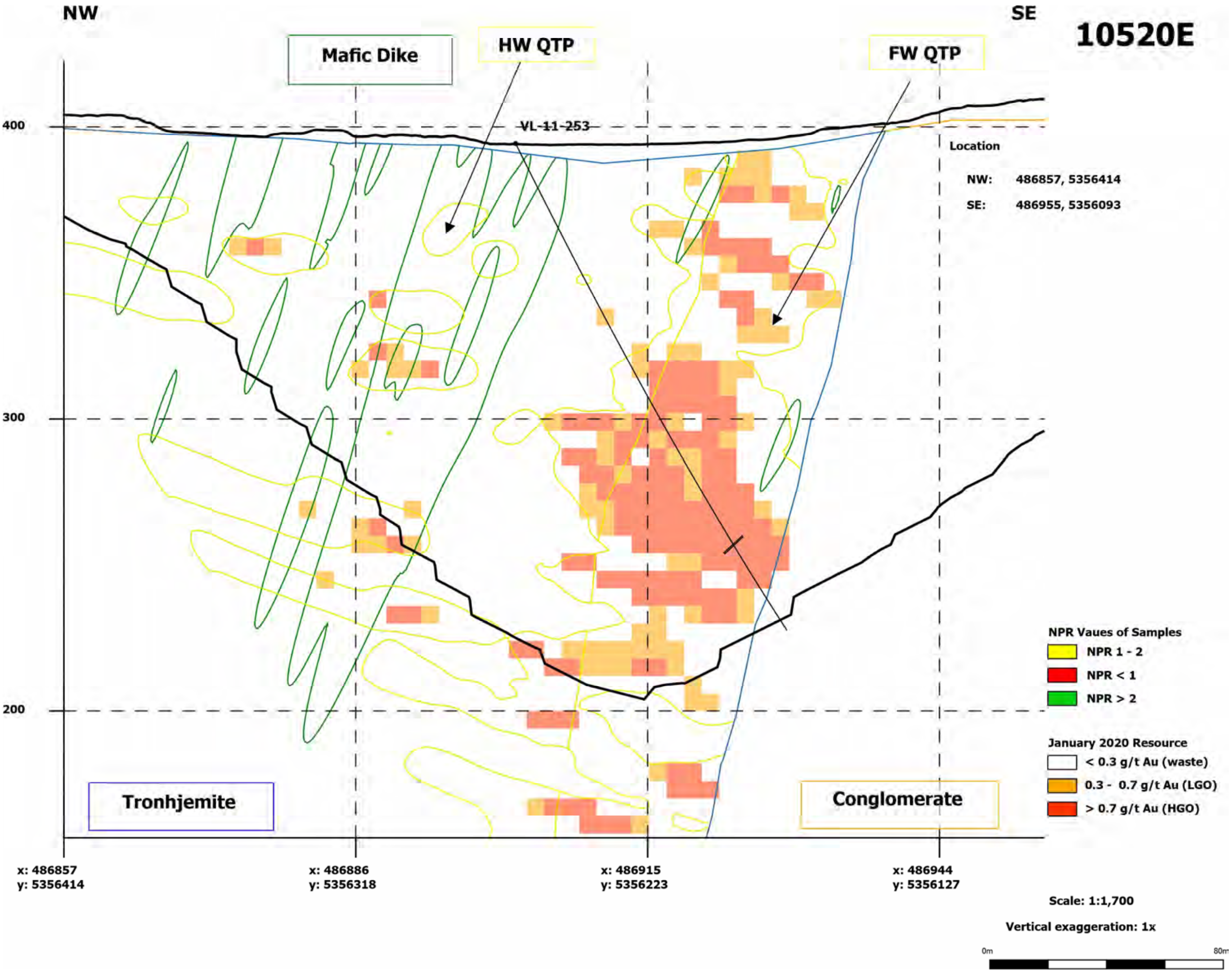
🟧 0.3 - 0.7 g/t Au (LGO)

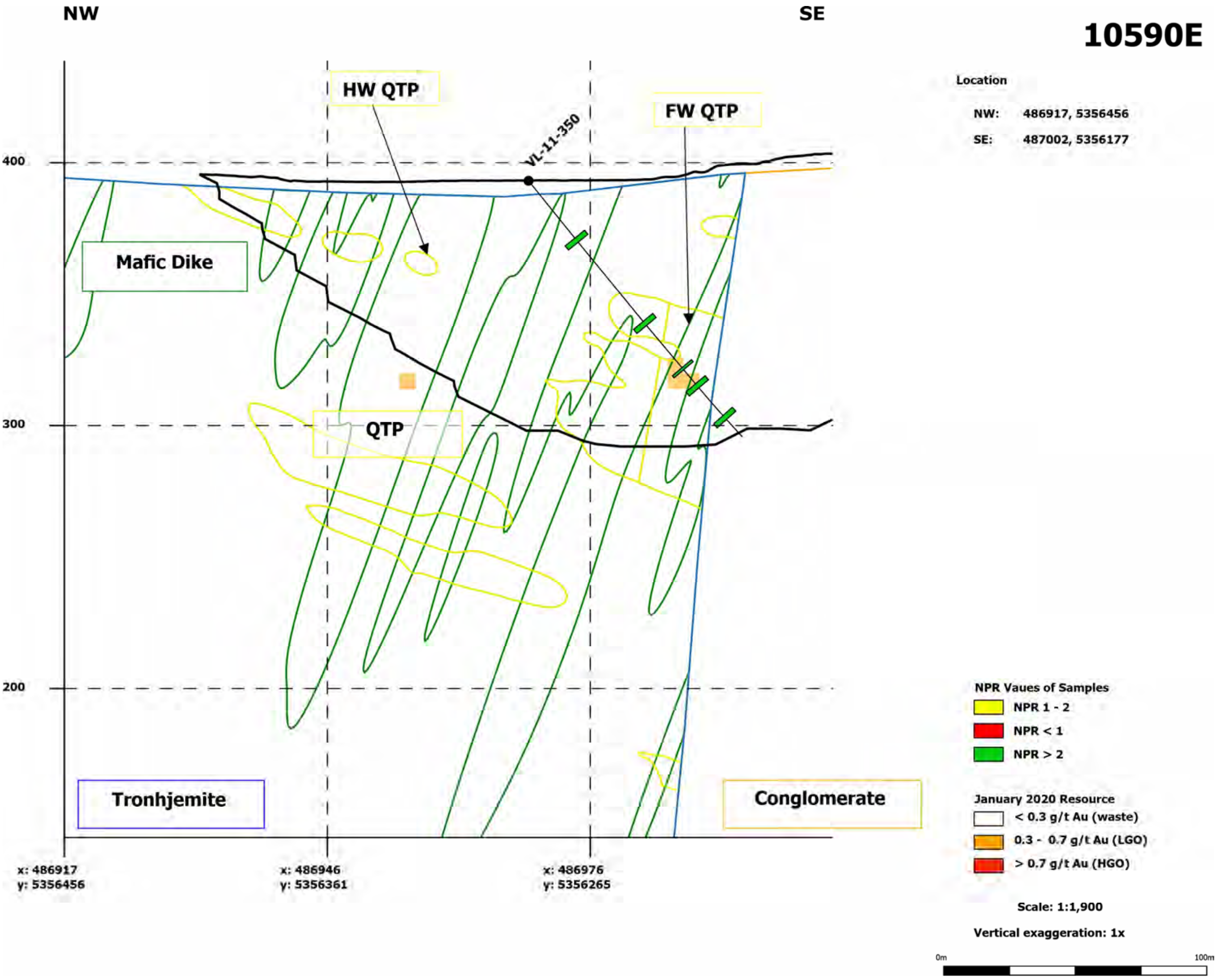
🟥 > 0.7 g/t Au (HGO)

Scale: 1:3,000

Vertical exaggeration: 1x

0m 200m


NW
SE
10520E
Mafic Dike
HW QTP
FW QTP
400
300
200
VL-11-253
Location
NW: 486857, 5356414
SE: 486955, 5356093
Tronhjemite
Conglomerate
NPR Vaues of Samples
NPR 1 - 2
NPR < 1
NPR > 2
January 2020 Resource
< 0.3 g/t Au (waste)
0.3 - 0.7 g/t Au (LGO)
> 0.7 g/t Au (HGO)
x: 486857
y: 5356414
x: 486886
y: 5356318
x: 486915
y: 5356223
x: 486944
y: 5356127
Scale: 1:1,700
Vertical exaggeration: 1x
0m
80m


NW
SE
10590E
Location
NW: 486917, 5356456
SE: 487002, 5356177
HW QTP
FW QTP
VL-11-350
400
300
200
Mafic Dike
QTP
Tronhjemite
Conglomerate
x: 486917
y: 5356456
x: 486946
y: 5356361
x: 486976
y: 5356265
NPR Vaues of Samples
🟨 NPR 1 - 2
🟥 NPR < 1
🟩 NPR > 2
January 2020 Resource
☐ < 0.3 g/t Au (waste)
🟧 0.3 - 0.7 g/t Au (LGO)
🟥 > 0.7 g/t Au (HGO)
Scale: 1:1,900
Vertical exaggeration: 1x
0m
100m

APPENDIX IR-19.A
ARD/ML MANAGEMENT PLAN

Appendix IR-19.A

ARD/ML Assessment and Management

Marathon completed a Phase 1 and 2 Acid Rock Drainage/Metal Leaching (ARD/ML) assessment prior to submission of the EIS, using methods that followed the Mine Environment Neutral Drainage (MEND) publication entitled "Prediction Manual for Characterizing Drainage Chemistry from Sulphidic Geologic Materials" (Price 2009). These geochemistry baseline programs included:

- Static testing of approximately 350 samples of waste rock, ore, overburden, and tailings for Acid-Base Accounting (ABA), Shake Flask Extraction (SFE), and total metals
- Characterization of composite samples using the static tests and mineralogical methods
- Kinetic testing of composite samples including 14 humidity cells, two ageing tests and two subaqueous columns tests

As a result of this test work, the following key geochemical characterization information has been determined, which has informed the environmental assessment, as well as the ongoing and follow-up phases of sampling, testing, and assessment work:

Leprechaun Deposit

Approximately 1.9 Mm^3 of overburden will be excavated from the Leprechaun open pit. Overburden is classified as non-PAG material with no exceedances of the MDMER limits in leach testing.

Less than 0.5% of the approximately 50 Mm^3 of Leprechaun waste rock is classified as PAG. Overall, the waste rock pile is not expected to generate ARD due to the small amount of PAG material and significant excess of NP. Therefore, specific ARD management of waste rock is not required. Furthermore, there are no exceedances of MDMER limits observed in humidity cell leachates.

About 10% of low-grade ore is estimated to be PAG, but overall is not expected to generate ARD within the relatively short residence time of low-grade ore in the stockpile. While kinetic testing suggests moderate leaching potential for Al and P, there are no exceedances of MDMER limits observed in these tests.

Marathon Deposit

Approximately 4.4 Mm^3 of overburden will be generated from the Marathon open pit. Overburden is classified as non-PAG material. There are no exceedances of MDMER limits observed in SFE leachates from overburden. Based on current materials balance over the life of mine, all of the stockpiled overburden will be used during rehabilitation and closure.

Approximately 14% of the 60 Mm^3 of waste rock is conservatively estimated to be PAG. Blending PAG and non-PAG rock with excess of neutralization potential and/or encapsulation of PAG waste by non-PAG rock is recommended to neutralize acidity potentially generated in isolated pockets of PAG material. The waste rock pile will be covered by growth medium / overburden during rehabilitation, further reducing the risk of ARD/ML. There are no exceedances of MDMER limits observed in leachates from the waste rock humidity cells.

Approximately one-half of the low-grade ore is conservatively classified as PAG. The ARD onset time in PAG low-grade ore is conservatively estimated at six years based on maximum laboratory leaching rates. There are no exceedances of MDMER limits observed in leachates from low-grade ore under neutral conditions. In the mine plan, the Marathon low-grade ore stockpile runoff and toe seepage has been segregated from other mine component flow streams to facilitate collection and further ARD treatment, if required.

Plant Site

High-grade ore from the Leprechaun and Marathon deposits will be stockpiled together with 30% of the material originating from Leprechaun and the reminder from Marathon, on average. Approximately 13% and 67% of ore samples from Leprechaun and Marathon pits, respectively, are conservatively classified as PAG. The overall mixture of Leprechaun and Marathon high-grade ores classifies as non-PAG and the high-grade ore stockpile is not expected to generate ARD. Drainage from the high-grade ore stockpile flows by gravity to the TMF and any potential acidity will be neutralized in the decant pond or in the mill during pH adjustment required as a part of the gold recovery by cyanide process. No exceedances of MDMER are observed in SFE extracts.

Approximately 41 Mt of tailings will be produced from both high-grade ore and low-grade ore with about 38% of the tailing originating from the Leprechaun pit and the remainder from the Marathon pit. Composite samples of tailings from both deposits are non-PAG and are not expected to generate ARD. During operation, TMF pond and seepage will likely exceed the MDMER limits for $CN_{(T)}$, un-ionized NH_3, and Cu sourced from process water. After closure, tailings beaches covered by soil are not expected to produce acidic runoff and/or have high metal leaching. Seepage from the TMF is conservatively predicted to exceed MDMER limits for $CN_{(T)}$, un-ionized NH_3, and Cu in post-closure and will be addressed in the long term through passive treatment methods.

Marathon is confident, based on the results of the testing and analysis conducted to date and as outlined above, that employing the following mitigation measures will address the potential geochemical effects associated with planned Project components and activities:

- PAG rock will not be used in construction
- Preferential milling of PAG ore and stockpiling non-PAG ore
- Blending PAG and non-PAG materials and encapsulation of blended material with non-PAG rock within the waste rock piles
- Use of soil covers and revegetation to limit infiltration and oxygen flux as part of progressive and final rehabilitation and closure
- Relocation of any excess of PAG rock (waste rock or low-grade ore) remaining at closure to the mined-out pit, where it will be permanently flooded
- Collection and monitoring of contact water during operation, and treatment if required (adaptive management).

As outlined in the EIS, and further addressed in the IR responses provided, as a result of having a less than ideal number of tests completed to date Marathon has utilized a very conservative approach in the assessment of effects from potential geochemical conditions. The limitations in the sampling and test work are a result of several factors, including an exploration focus on mineralized targets and impacts to Marathon's drilling programs over the past year due to COVID-19. Marathon recognizes that further ARD/ML work is required to fully conform to the MEND guidelines and further refinement of Project mitigation is progressing as design of the Project proceeds. Additional ARD/ML testing, as outlined below, will refine the results obtained to date and the associated mitigation measures identified that will be incorporated into the mine plans, waste rock management, stockpile management, and tailings management via the ARD/ML Management Plan such that PAG materials are managed to minimize any potential long-term effects.

Marathon is committed to completing the work necessary to address testing gaps identified in the program completed to date, and as noted by NRCan, within the next 6 to 8 months and prior to construction. The results of this work are required for final design and permitting under the *NL Mines Act* (NL Department of Industry, Energy, and Technology), and will be shared with NRCan as it becomes available:

- Continuation of on-going laboratory and field tests started in 2020. Laboratory tests include two humidity cells containing carbonate depleted LGO and tailings from the Marathon deposit. Field bin tests of composite materials including nine composite samples representing major waste rock lithologies and low-grade ores from both deposits. In 2021, a subaqueous column, an aging test and a humidity cell will be started on samples from on-going metallurgical work.
- Additional static testing of samples:
  - to address spatial distribution and sampling requirements per lithology (see attached Tables 1 and 2)
  - to provide the data inputs required to develop an ARD block model for the Marathon pit
  - to better define the location and volumes of non-Potentially Acid Generating (non-PAG) rock, which is required for construction, in Leprechaun and Marathon starter pits
- Additional kinetic testing of Potentially Acid Generating (PAG) materials (waste rock, ore, and low-grade ore) from major lithologies of the Marathon pit including a composite sample of gabbro. These samples will also be submitted for static tests including Net Acid Generating (NAG) tests, mineralogy, and particle size distribution similar to characterization of composite samples as described in Section 3.2.2 of Attachment 5-B of the EIS.
- Generate an ARD block model for the Marathon pit to provide production schedules for ARD classes of rock and ore and to improve the estimates of PAG material exposures on pit walls.
- Update water quality predictions based on available results of kinetic tests, if required.

Marathon will provide the above information and analysis to regulators, including NRCan, for review and comment via the proposed ARD/ML Management Plan. This plan will be considered 'live' and will continue to be updated as required as additional ARD/ML information is obtained through the construction and operational phases of the Project. The ARD/ML Management Plan would contain the following sections:

Introduction

- **General Introduction**: Company and Project introduction.
- **Objective:** The objective of the ARD/ML management plan is to provide the most recent information and actions required to reduce the risks associated with ARD/ML during all phases of the Project.
- **Related Plans and Documents, Document Management:** List any related plans and documents, and describe document control for the ARD/ML document.

Background

- **Project Components and Activities:** This section will summarize Project components and activities which pose potential ARD/ML risks. This section will also describe the high-level development timelines and phases for each Project component and activity.
- **ARD/ML Assessment Summary:** This section will focus on the current understanding of ARD/ML potential related to each relevant component of the Project: Marathon and Leprechaun pits, two waste rock stockpiles, two low grade ore (LGO) stockpiles, high grade ore (HGO) stockpile, tailings management facility (TMF) and any rock quarries. The potential ARD/ML risks associated with these components will be (re)assessed for each phase of the Project based on the most recent results of geochemical testing, the ARD block model for the Marathon pit and any updated predictions of water quality.
- **Regulations and Management:** Outline regulatory documents that are applicable and will be followed as part of this Plan. Outline management requirements, personnel responsible, and their responsibilities under the Plan.

ARD/ML Management

- **Project Development:** Describe relevant development components, activities and phases in detail including mine waste material volumes and pit wall exposure for each Project component.
- **ARD/ML Management:** provide data and methods, and mitigation measures to be employed to manage PAG material generated from Project components and activities, separated by phases as appropriate.

  The following is an example method for the identification and the management of PAG rock and ore, which will be subject to further refinement as the ARD/ML Management Plan is developed:

  - Samples of drill cuttings from blast holes representing each mine block will be collected.
  - The samples will be tested for total carbon and sulphur using LECO furnace or similar method. Average neutralization potential (NP) will be calculated from total carbon and average Acid Potential (AP) will be calculated from total sulphur using standard conversions per the MEND guidelines. If NP/AP ratios indicate the mine block rock is below 2, the block will be classified as PAG.
  - PAG rock will be marked after the blast, excavated, and dispatched to the waste rock stockpile. PAG rock would only be deposited within a specified distance (to be defined) of the final stockpile shell and preferably next to a non-PAG truck load. Piled PAG rock will be marked, and the geospatial coordinates recorded.

- A portion of PAG and non-PAG rock loads will be mixed during grading each lift of the stockpile.
- This mixture will be encapsulated with non-PAG rock deposited within a specified distance (to be defined) from the lift face and forming the topmost lift(s) on the final of the stockpile. Non-PAG rock will reduce oxygen flux into interiors of the pile and provide alkalinity to infiltrating water. This approach has been successfully applied for waste rock piles in other mine sites as referenced in Sections 6.6.3.5 and 6.6.3.6 of Global ARD management guide (http://www.gardguide.com/index.php/Chapter) and would be applicable to ARD/ML management at the Valentine Gold Project.
- To limit exposure of PAG high grade ore, this material will be preferentially directed to the mill feed, while non-PAG high grade ore will be allocated to the stockpile, as long as the grade requirement for the mill feed is met.
- LGO stockpiles will be constructed to maximize non-PAG material in the feed in the last year of tailings deposition in the TMF to the extent practicable. This approach will create a non-PAG layer of tailings on the surface of the TMF prior to placement of the soil cover. This non-PAG layer will consume oxygen, reducing oxygen diffusion into tailings deposited earlier. In the last three years of operation, tailings will be deposited in the Leprechaun pit and immediately flooded limiting further oxidation and ARD/ML.

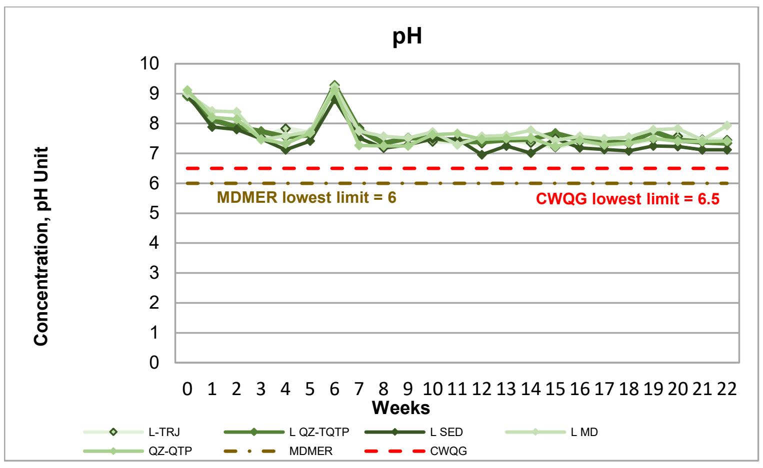
  This section will also detail progressive rehabilitation planned for waste rock and ARD/ML mitigation activities planned for the closure.

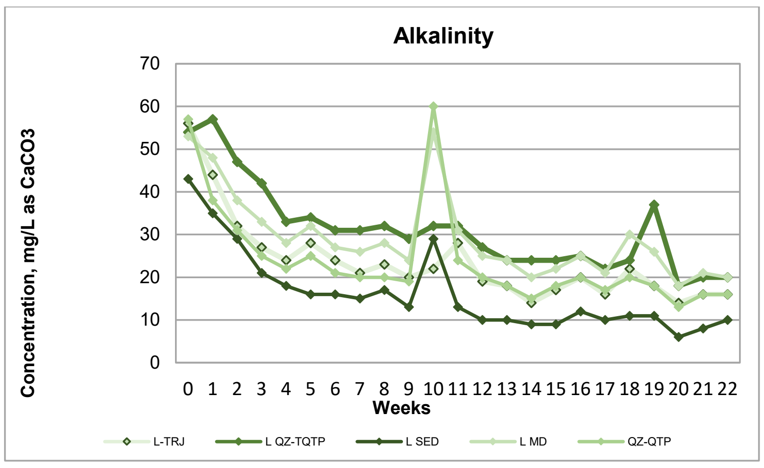
- **Monitoring, Ongoing Testing and Analysis:** This section will provide procedures for monitoring of contact water (e.g., the LGO seepage) and solids (e.g., tailings). This section will include details on monitoring locations, lists of monitoring parameters and sampling frequencies for each phase of the Project. Any further testing or analysis work (e.g., cover trials) related to ARD/ML will be described here.
- **Adaptive Management:** The adaptive management section will discuss additional mitigations that may be triggered by monitoring and/or by results of the future updates to the ARD/ML data. For example, if a certain volume of PAG waste rock cannot be accommodated within the waste rock stockpile at the Marathon pit at the end of operation, that volume could be stored within LGO stockpile footprint or west of the LGO. Another approach might be to build a seepage collection system and connect to the LGO sedimentation pond.

The ARD/ML management plan will be a “live” document, which will be updated and revised as information is gathered during the Project and in consultation with regulators.

APPENDIX IR-20.A
TIME-SERIES GRAPHS

Leprechaun waste rock humidity cells


pH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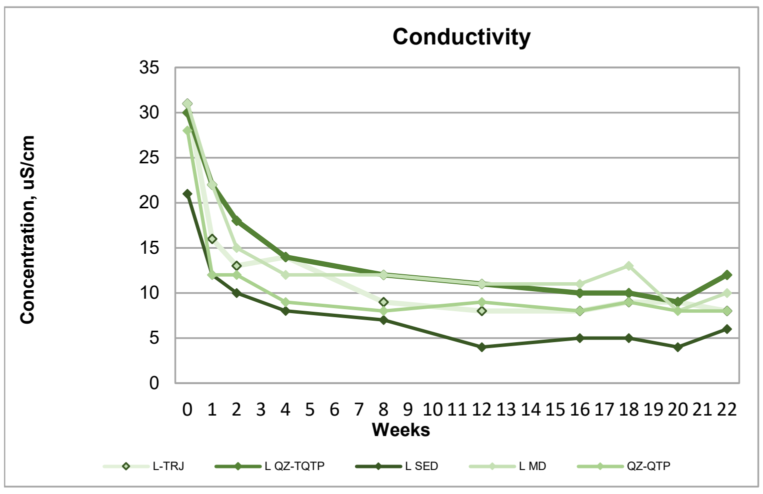
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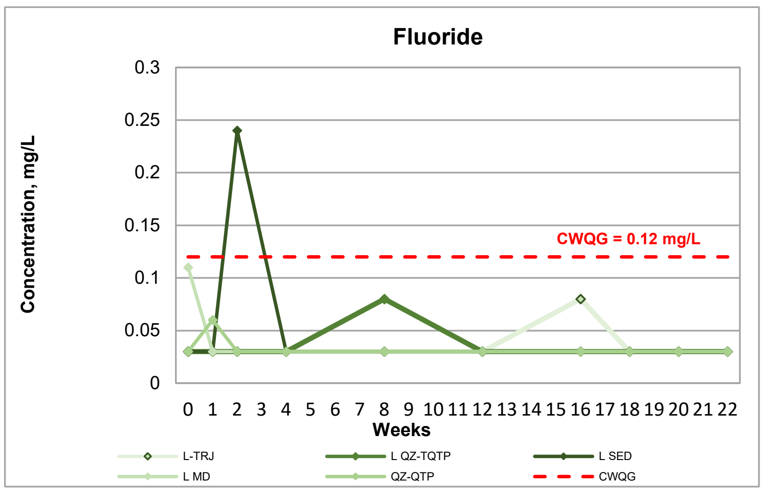
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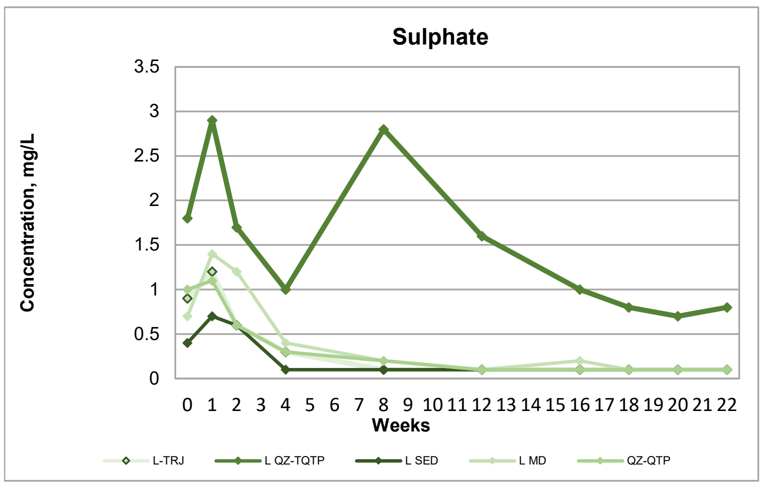
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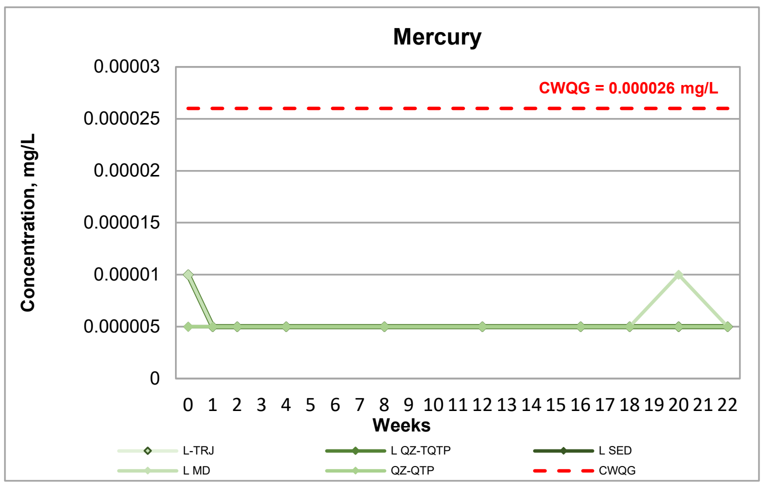
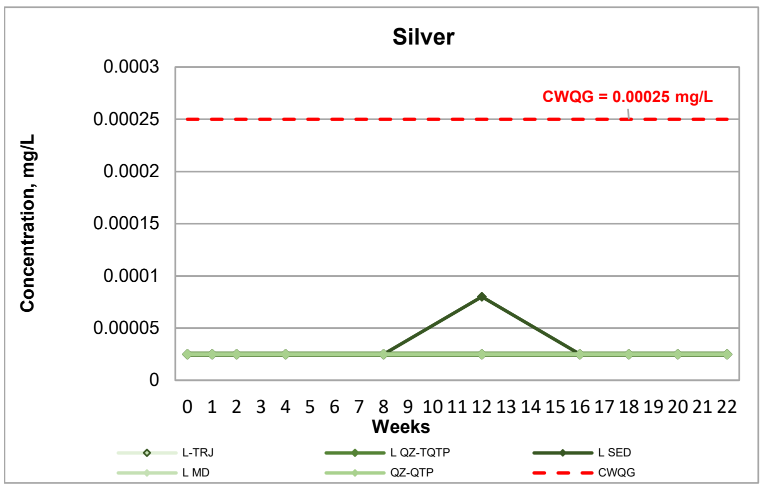

Mercury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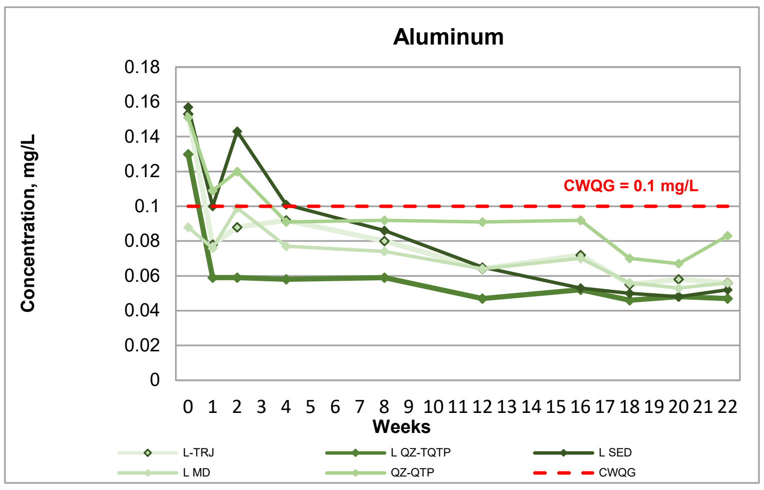
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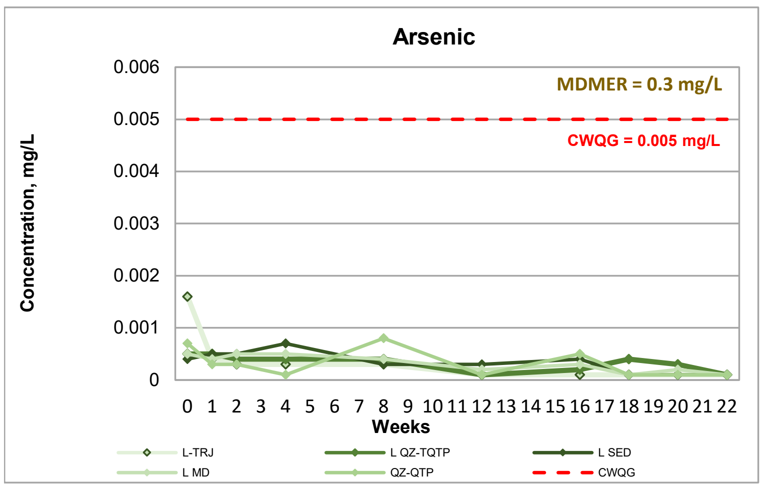
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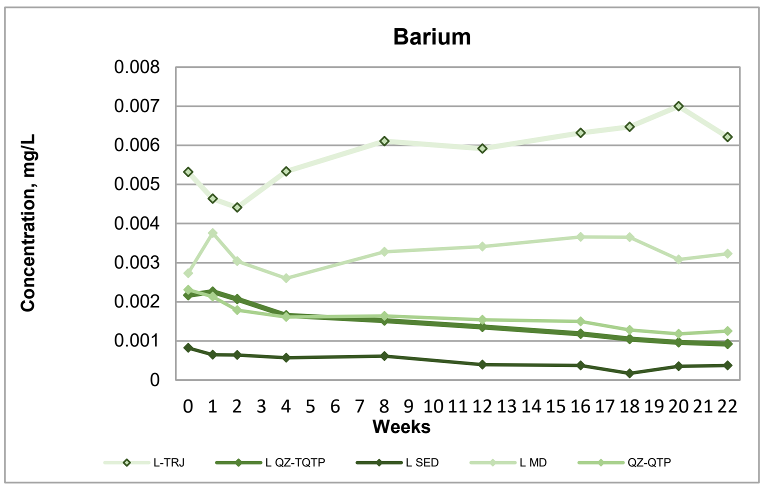
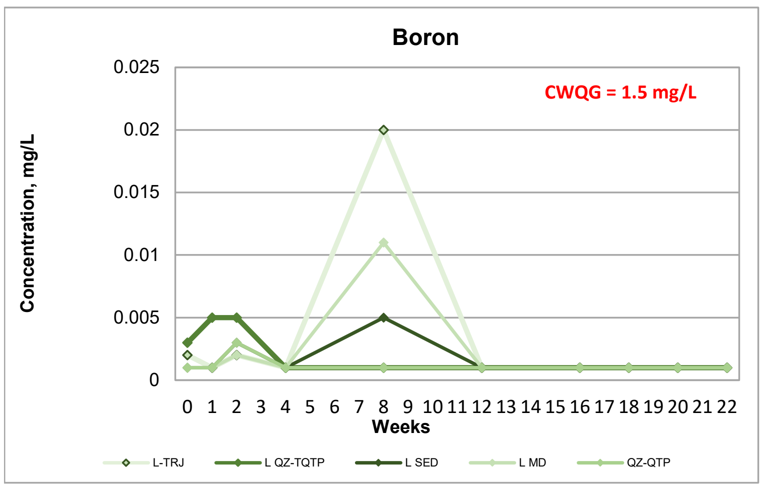

Barium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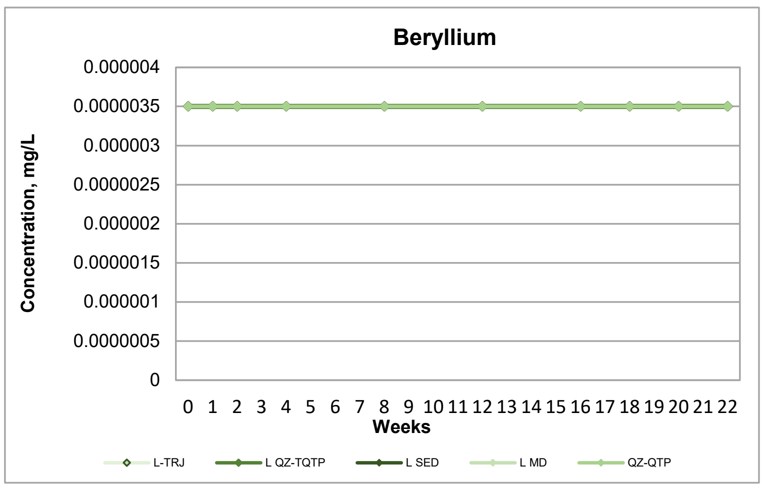
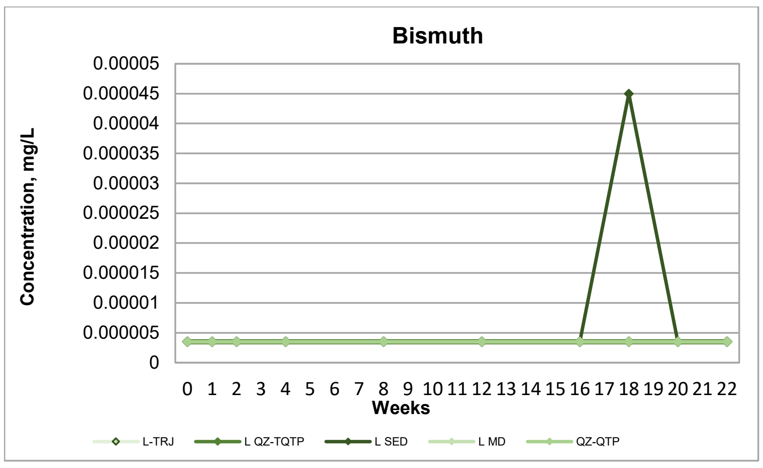
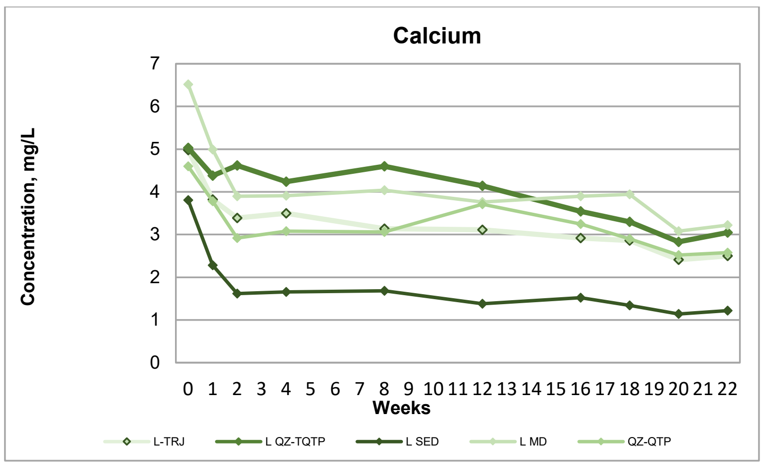
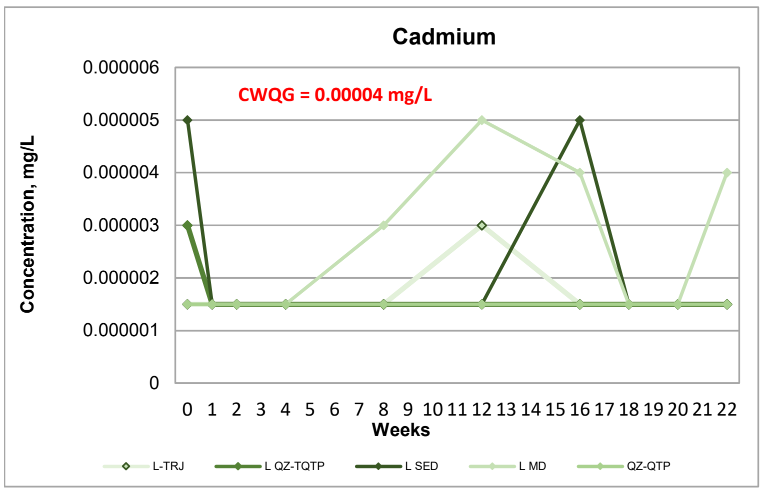

Beryllium

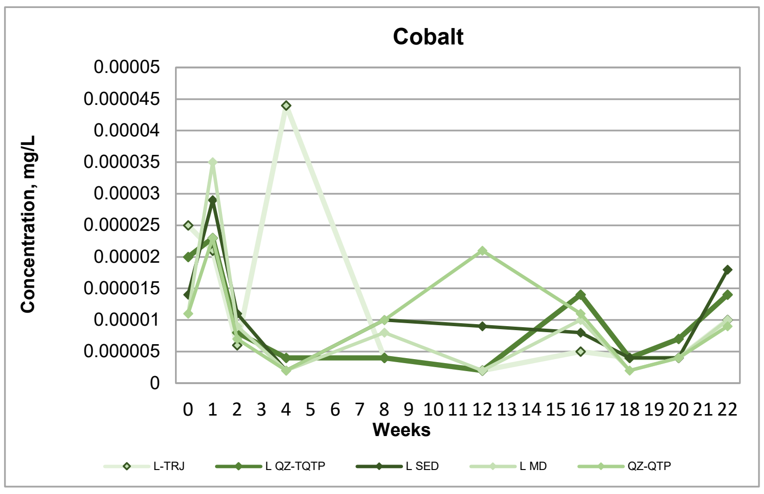
Note: Values below the respective detection limits (DLs) are shown as half DLs. CNWAD - weak acid dissociable cyanide.

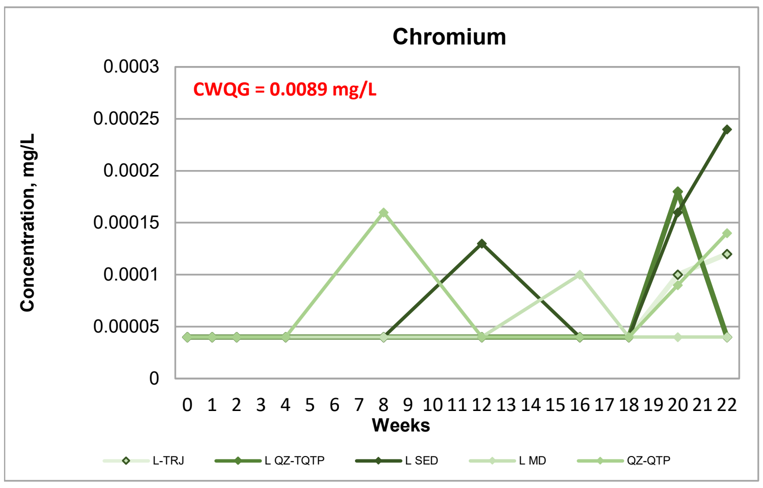
Leprechaun waste rock humidity cells

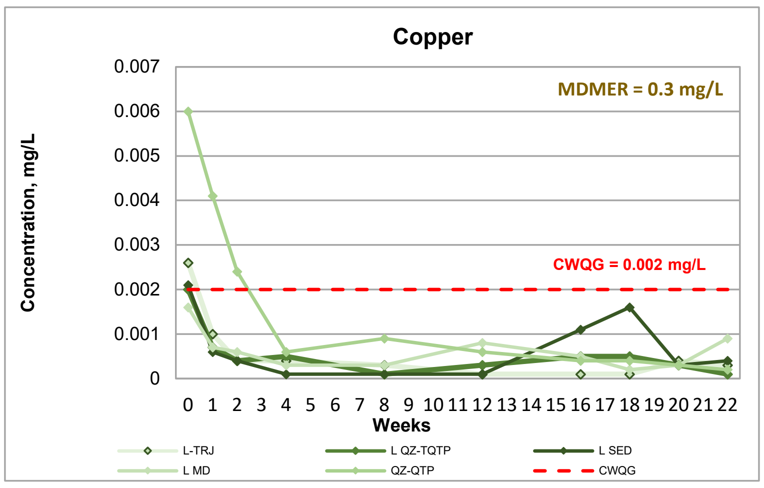


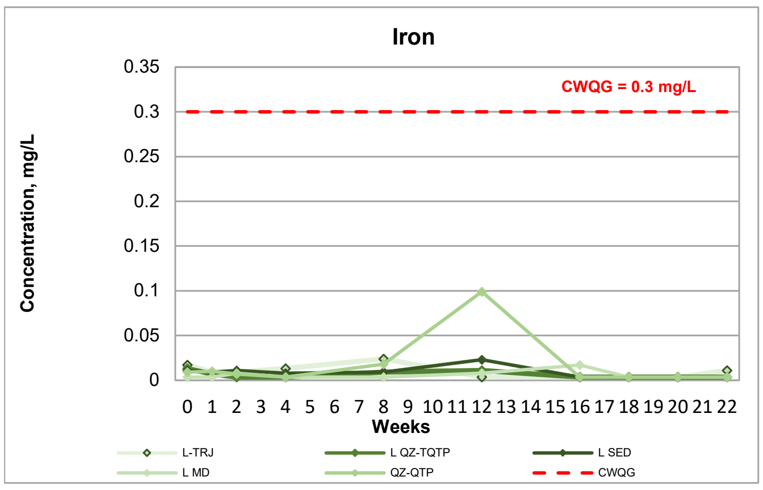


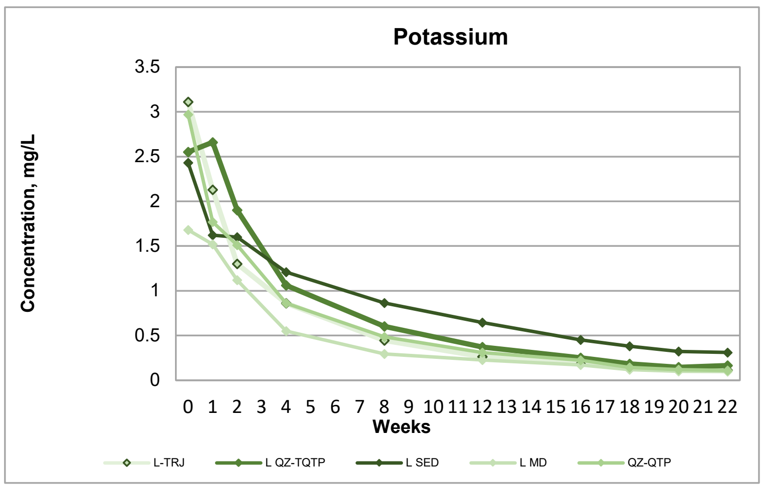


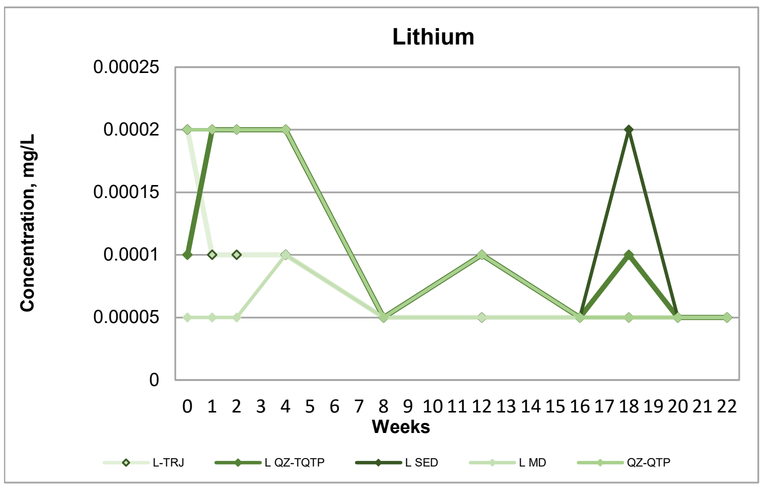


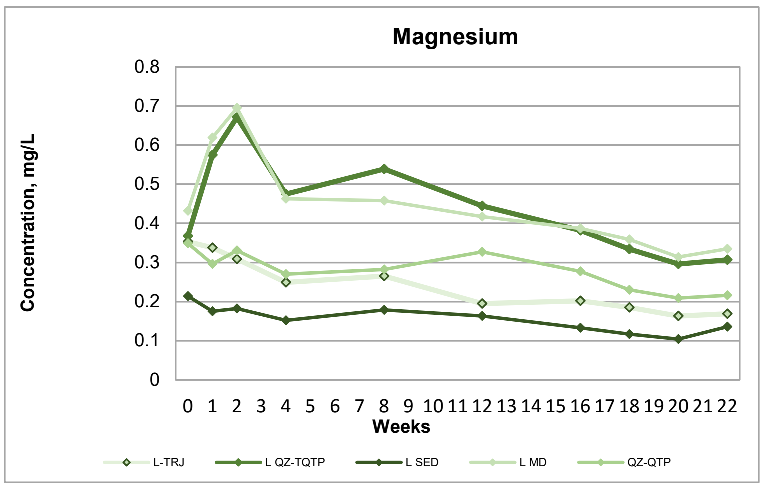


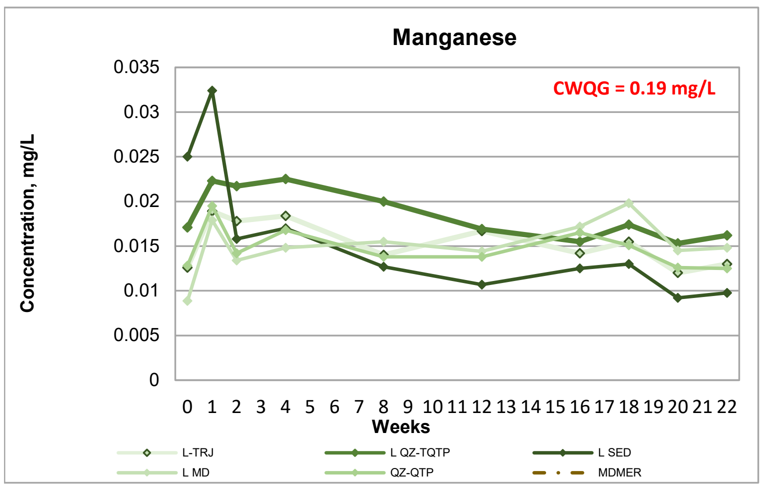


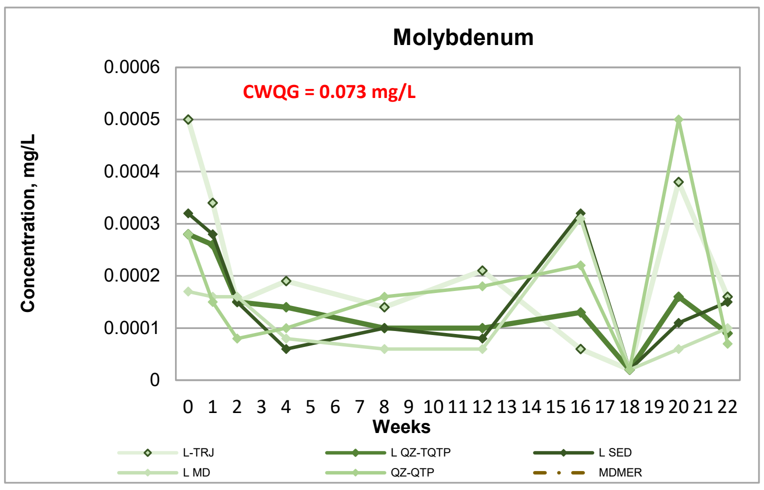






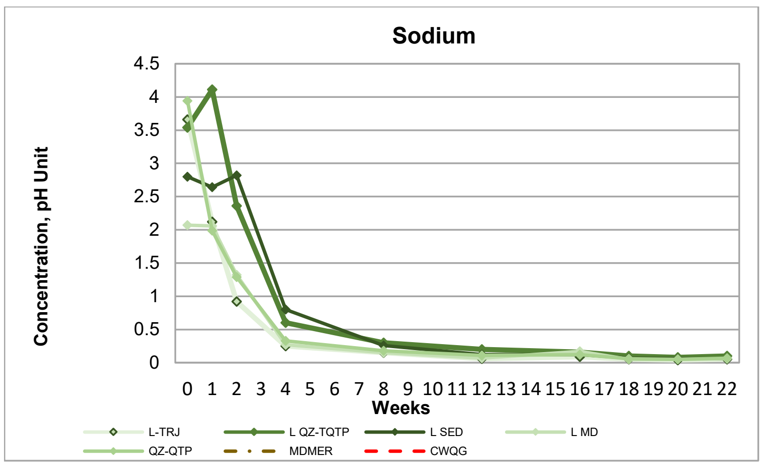


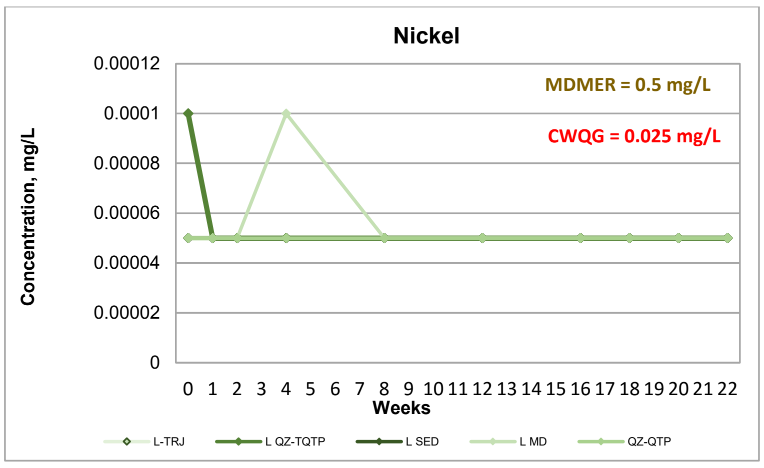


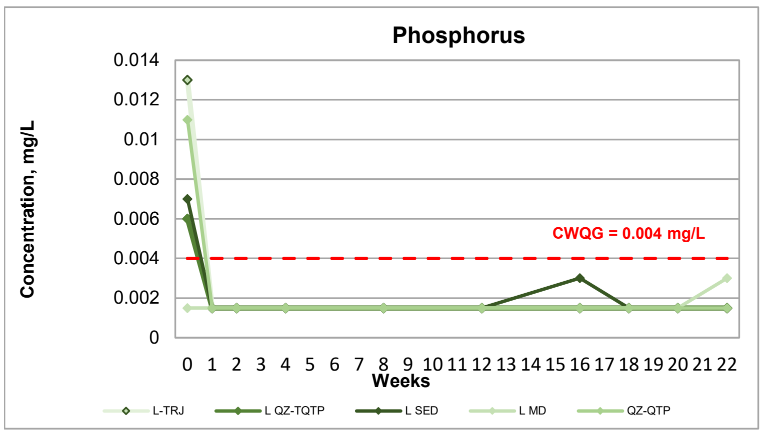


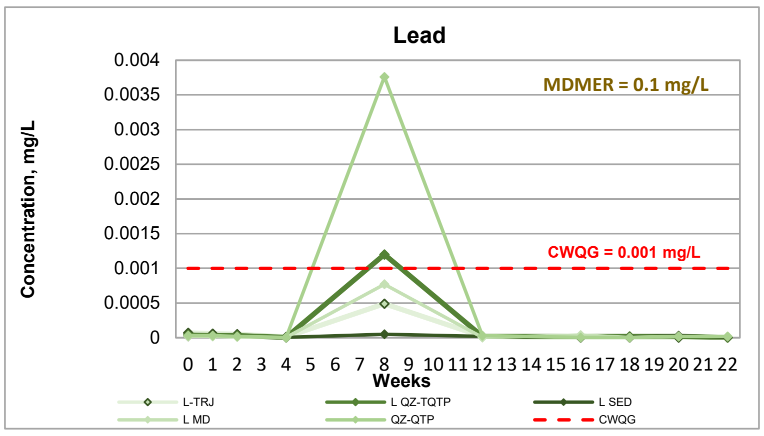
Note: Values below the respective detection limits (DLs) are shown as half DLs.

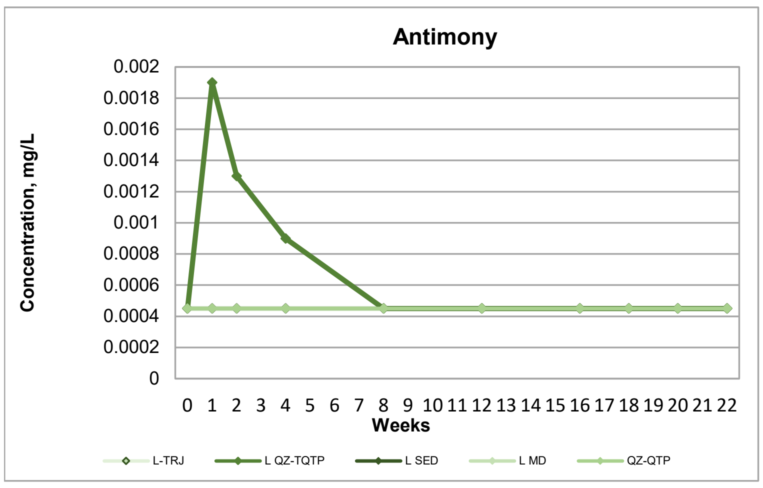
Leprechaun waste rock humidity cells

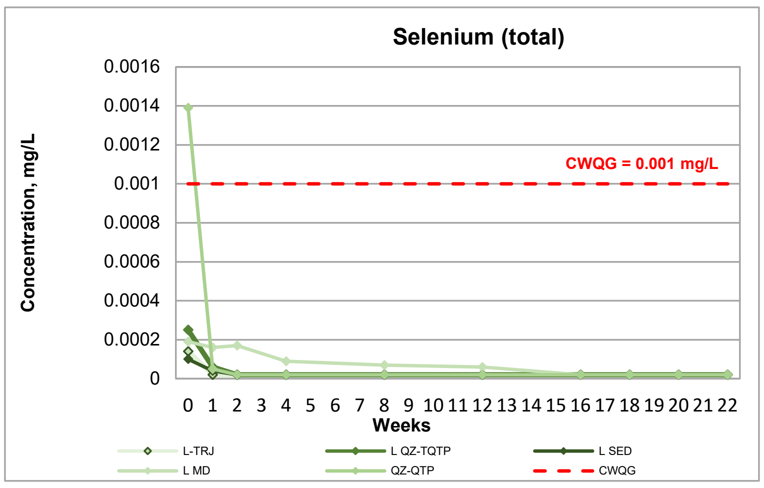


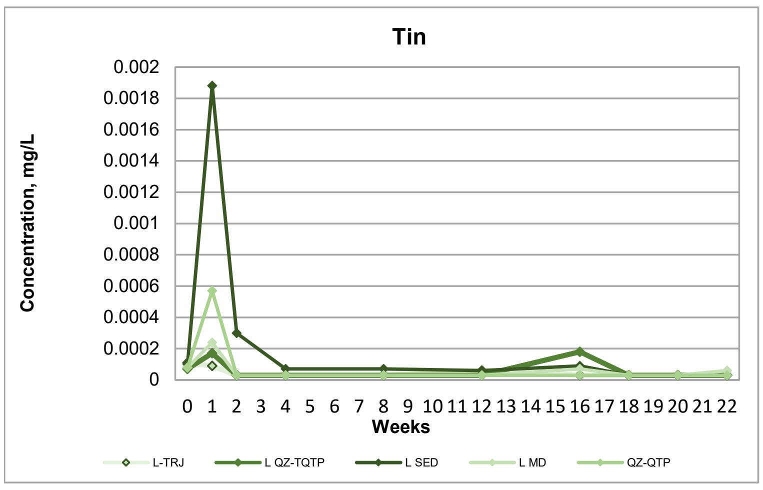


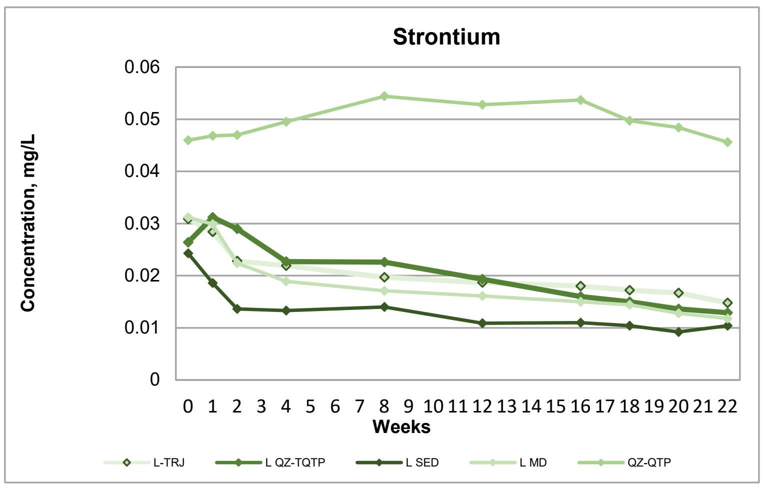


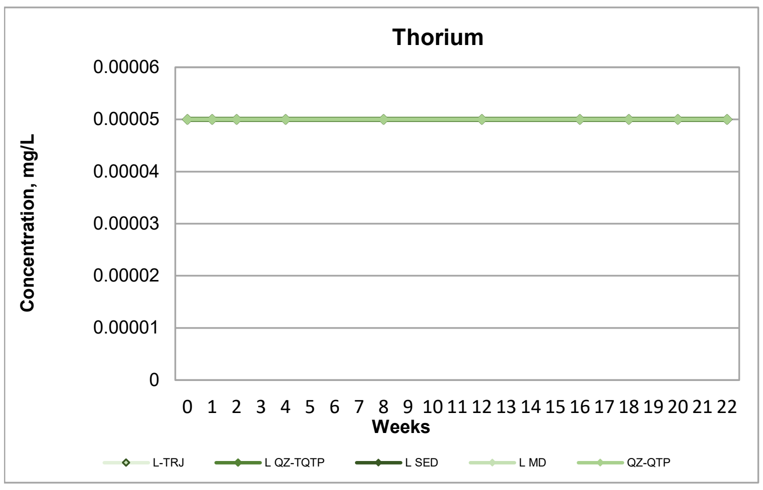


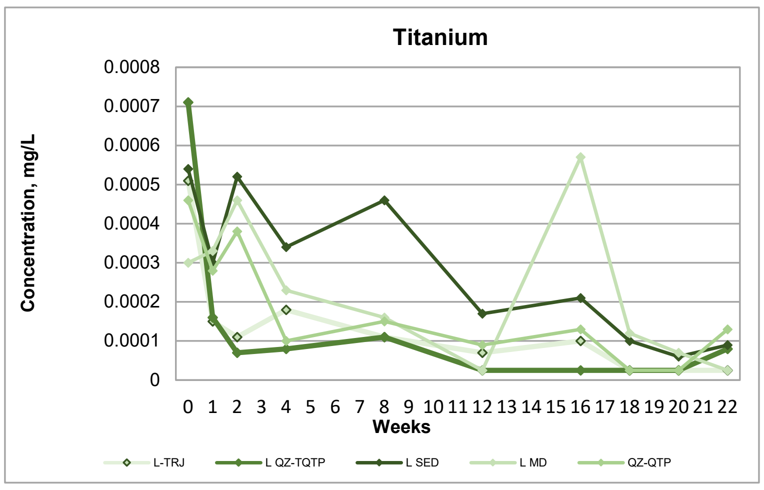


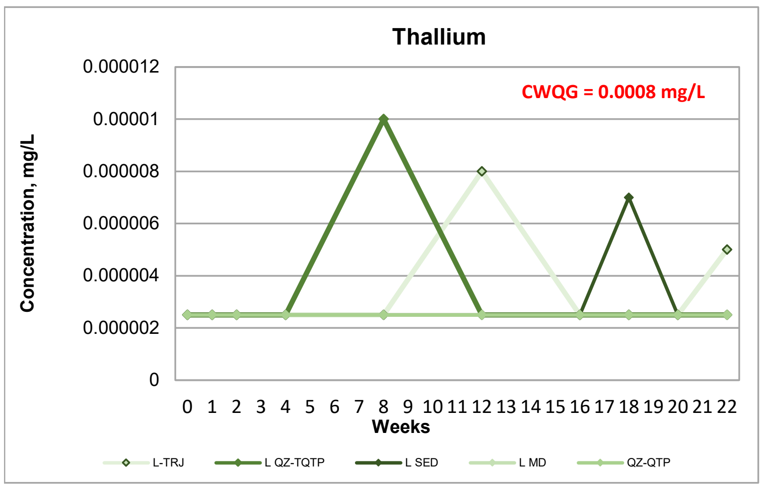


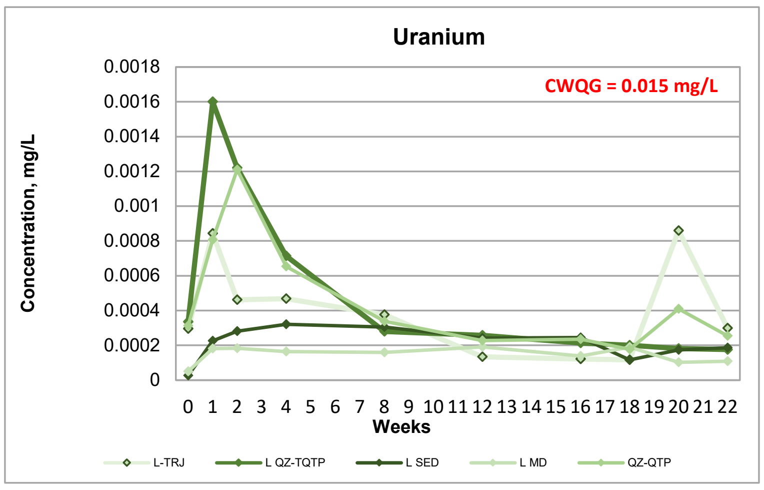












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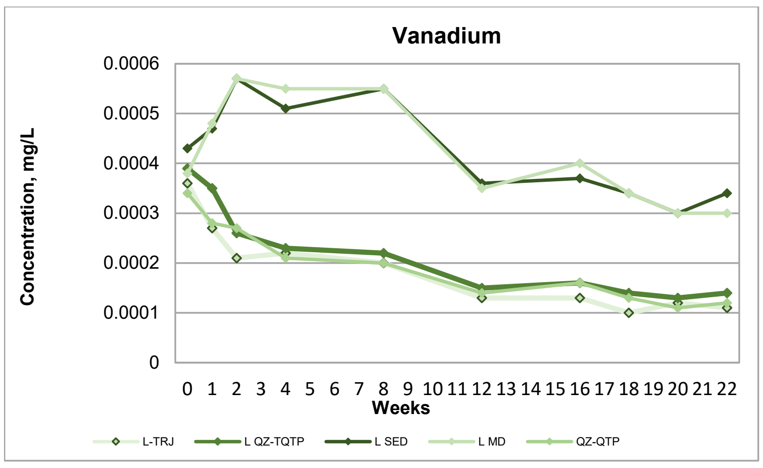
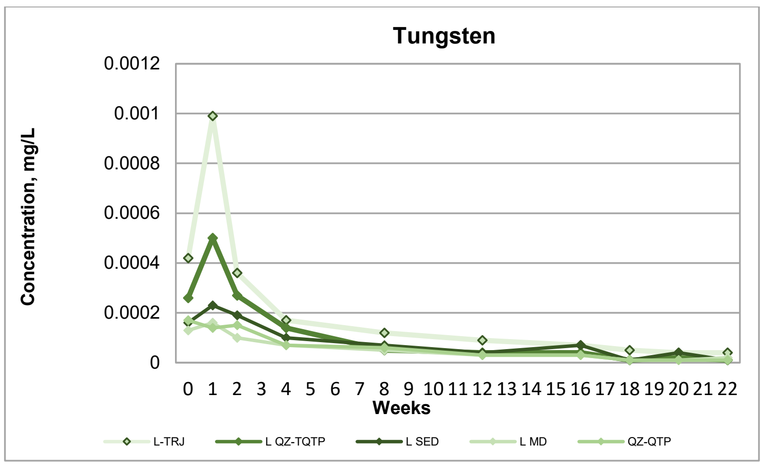
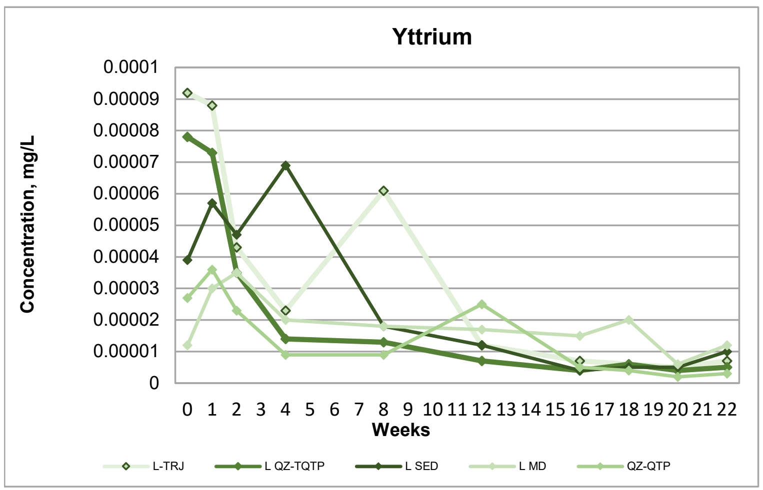
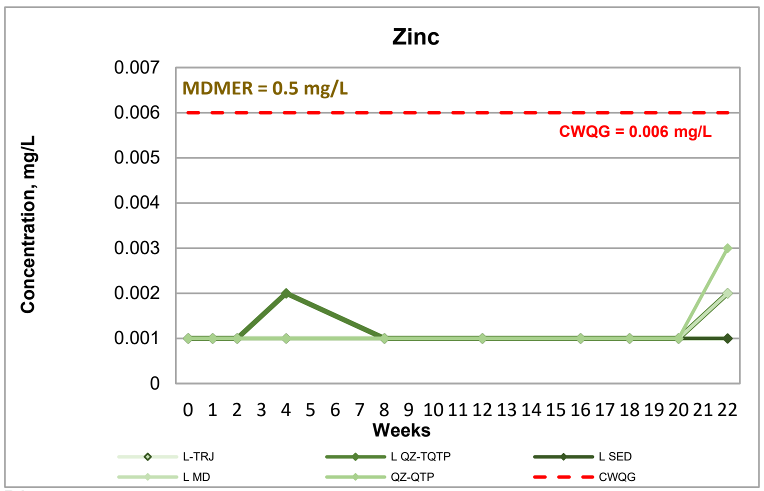
Leprechaun waste rock humidity cells









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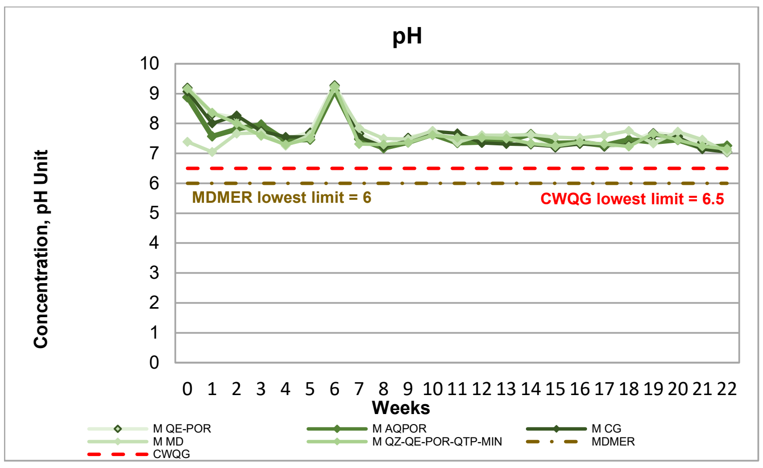
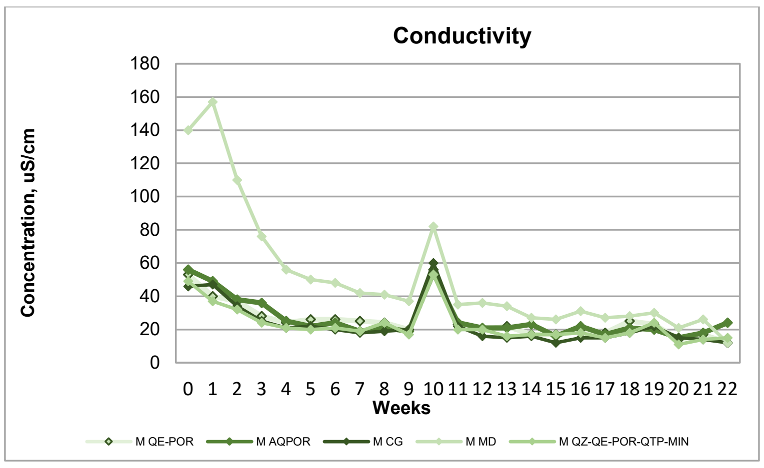
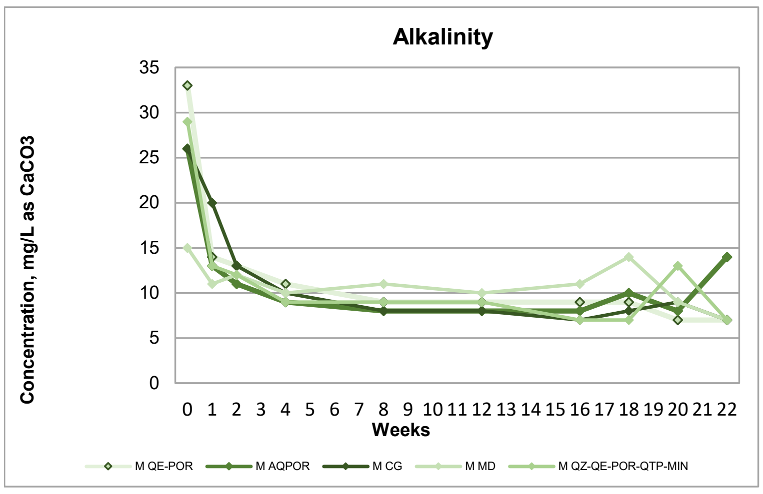
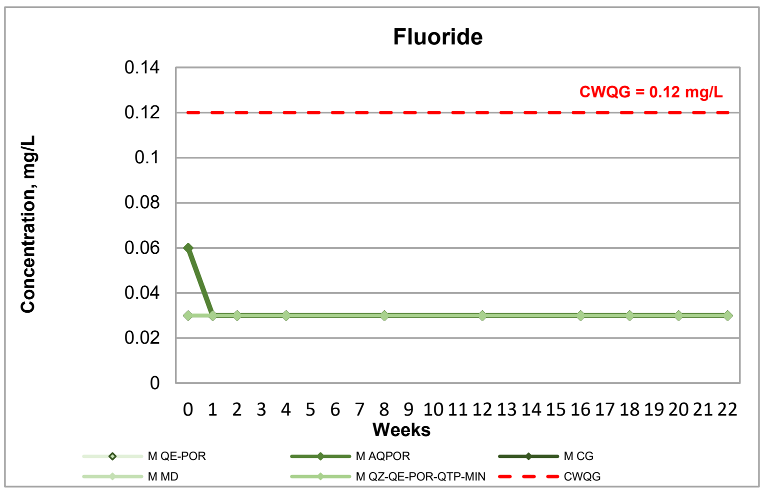
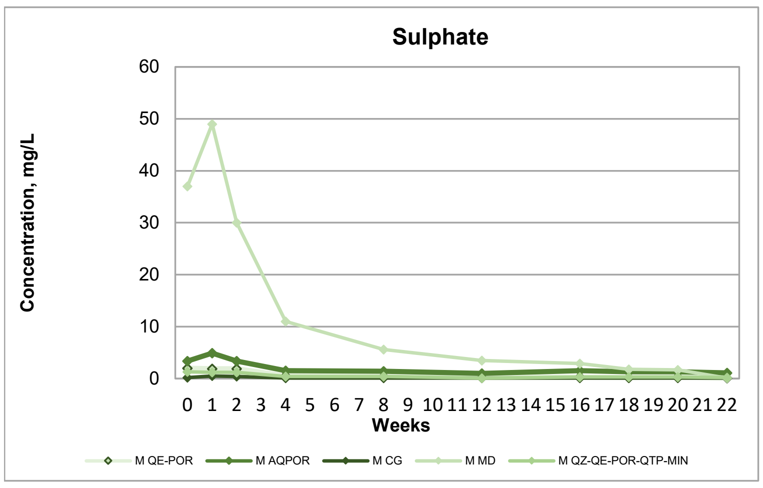
Marathon waste rock humidity cells

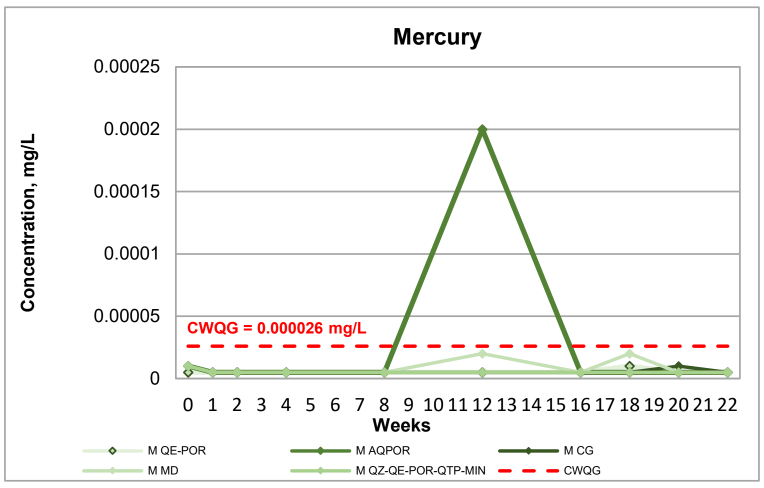


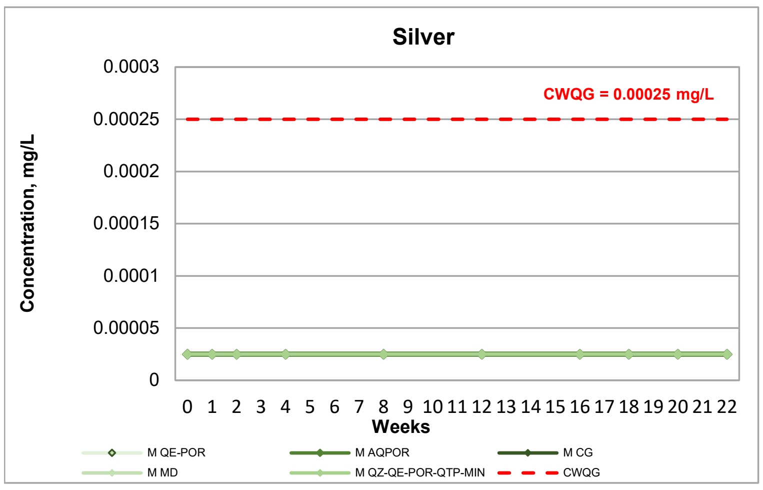


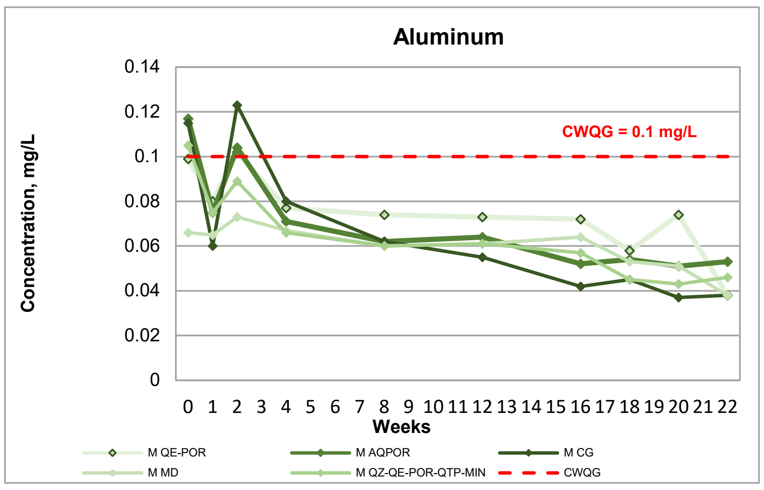


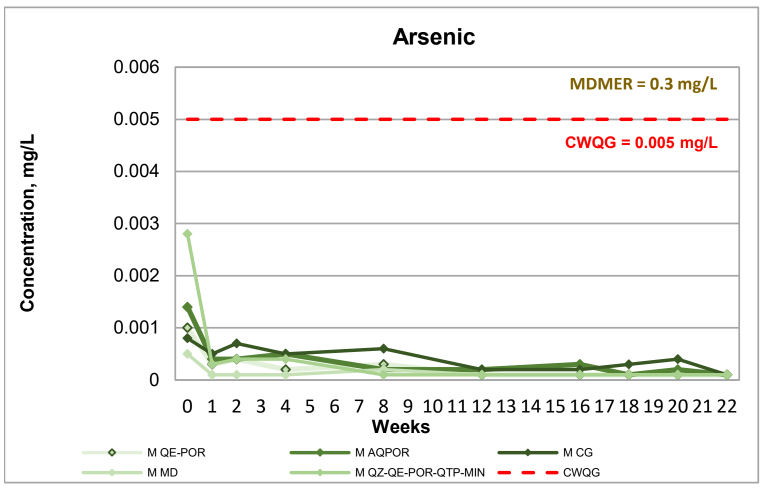


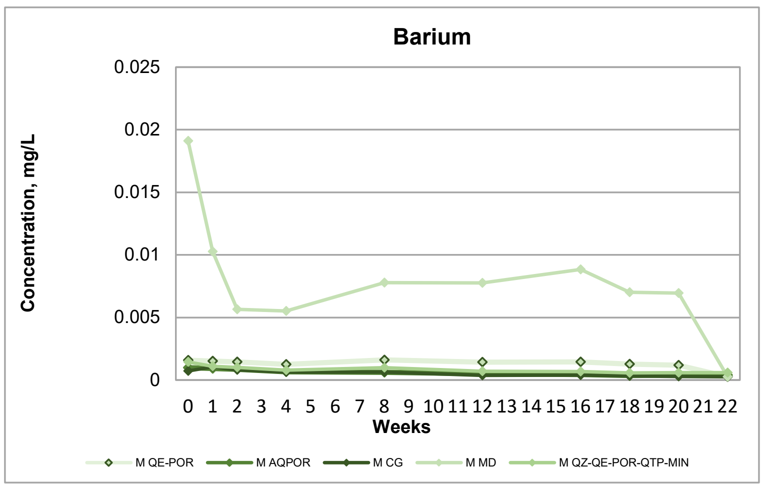


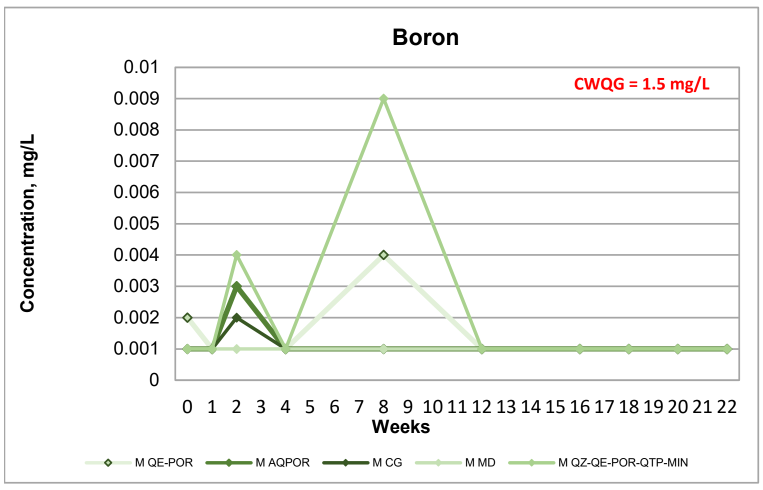


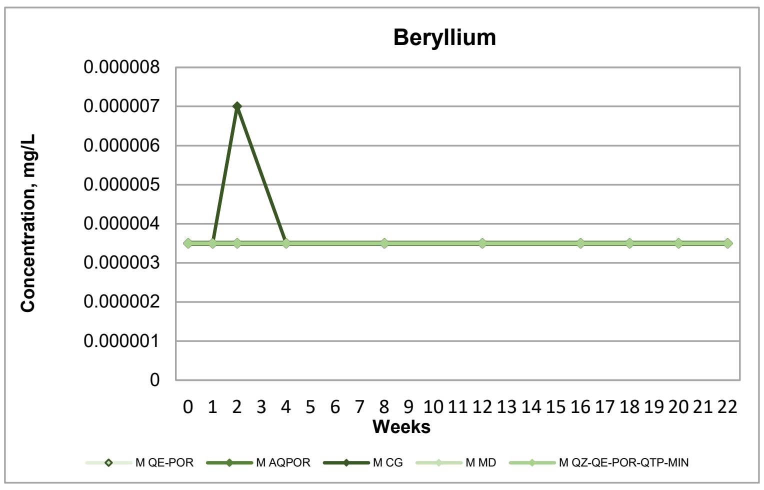












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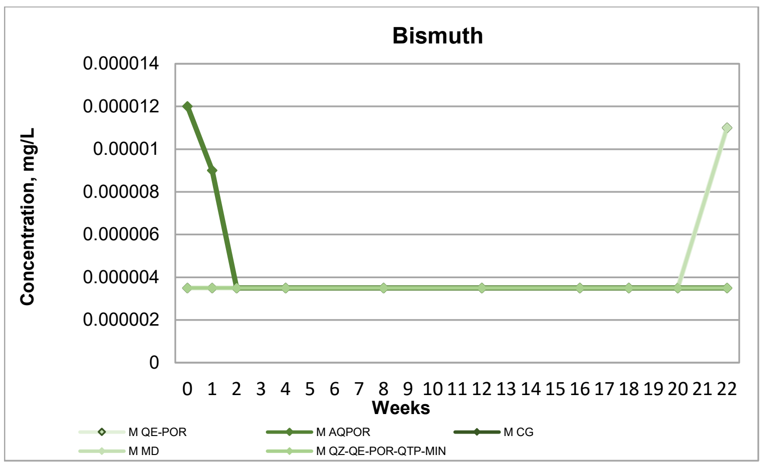
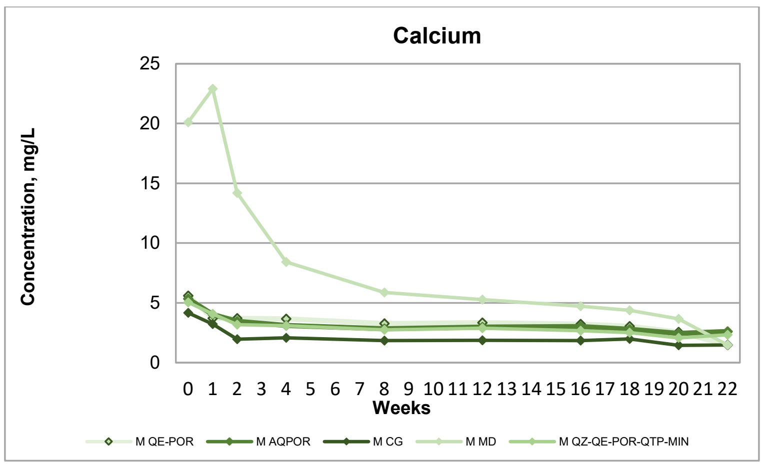
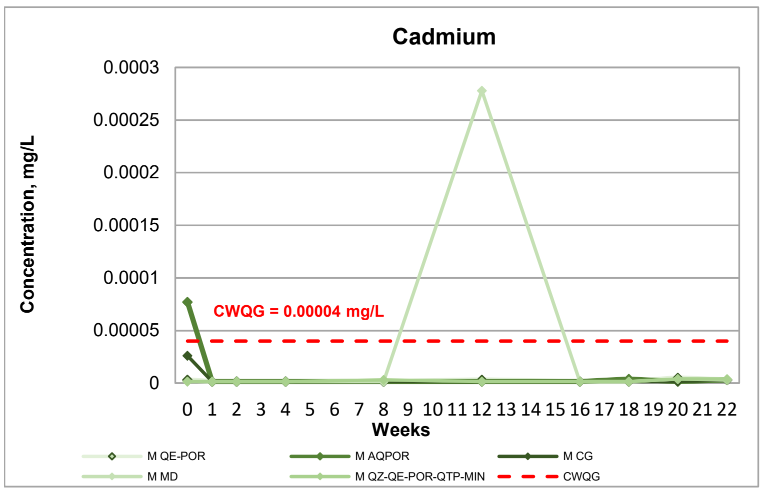
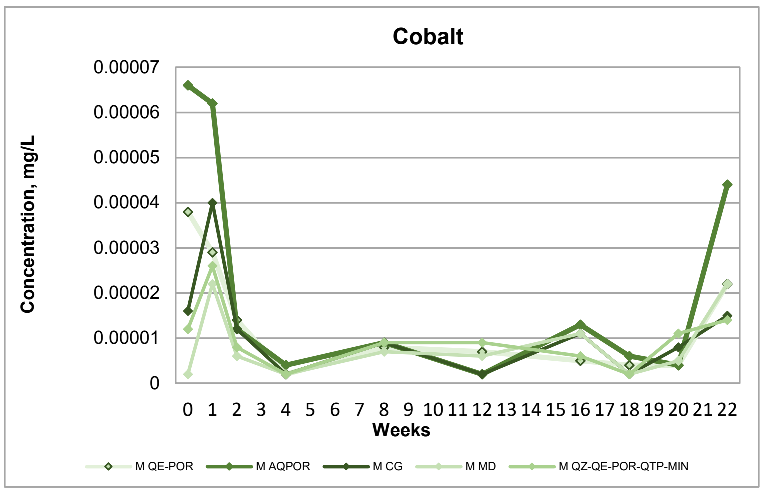
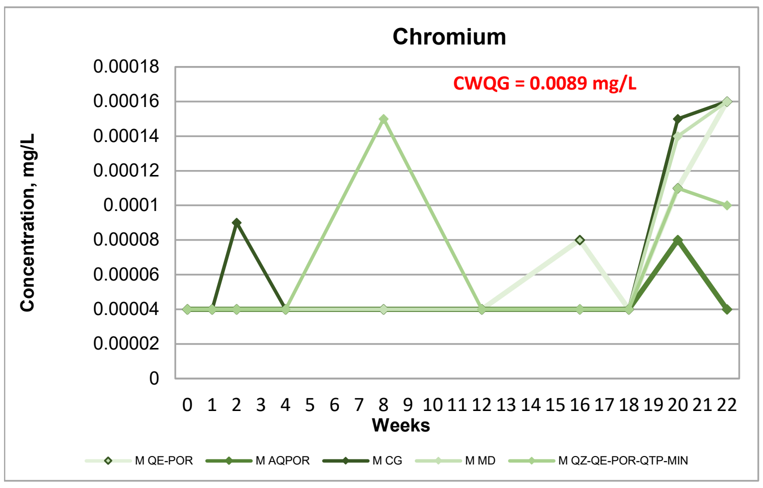
Marathon waste rock humidity cells

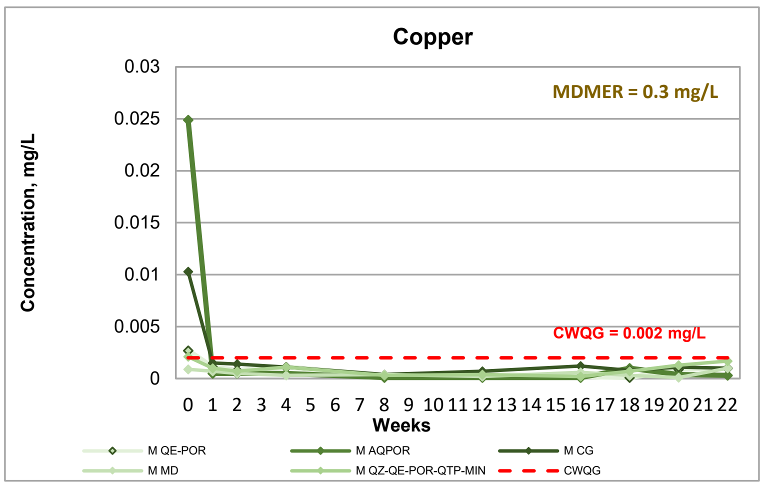


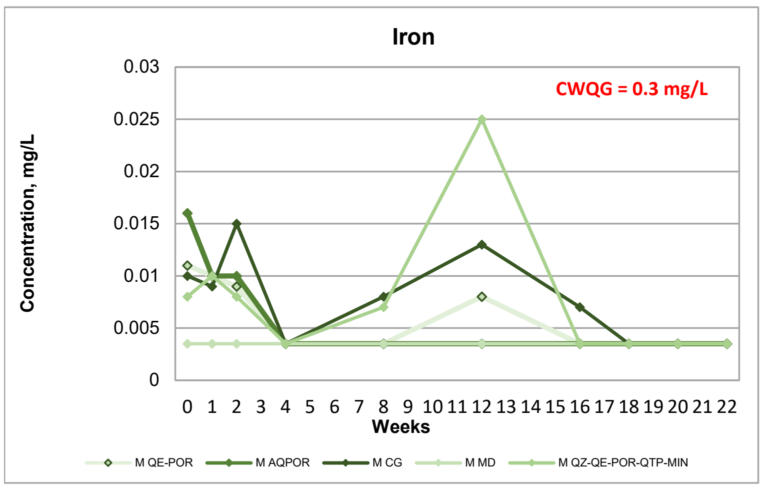


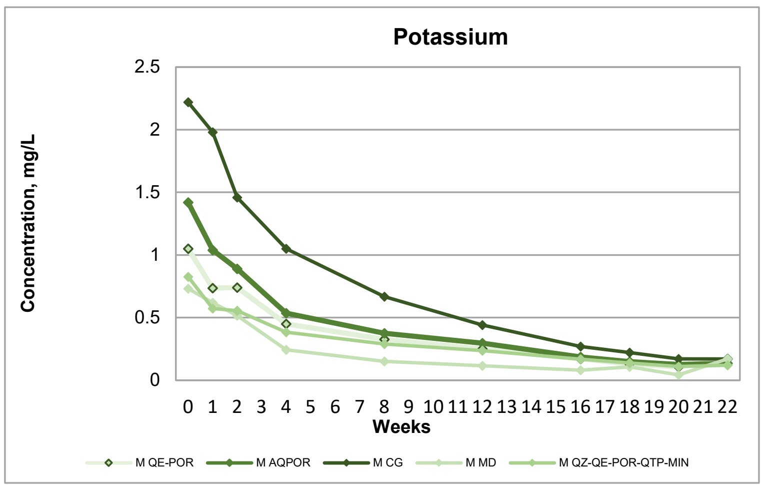


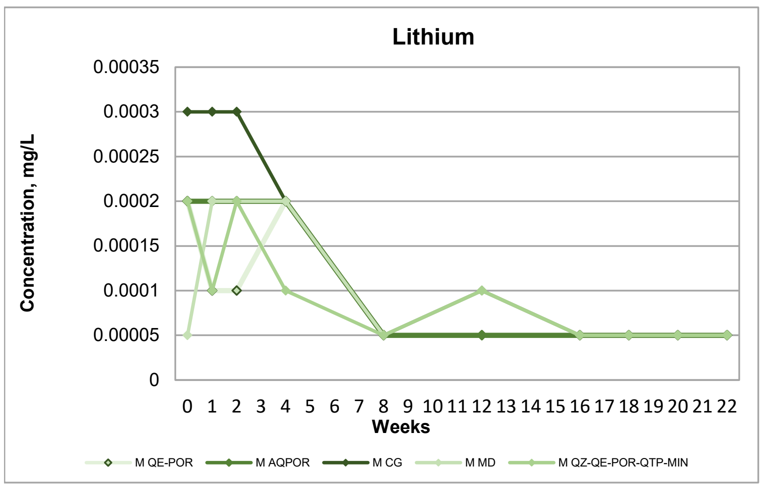


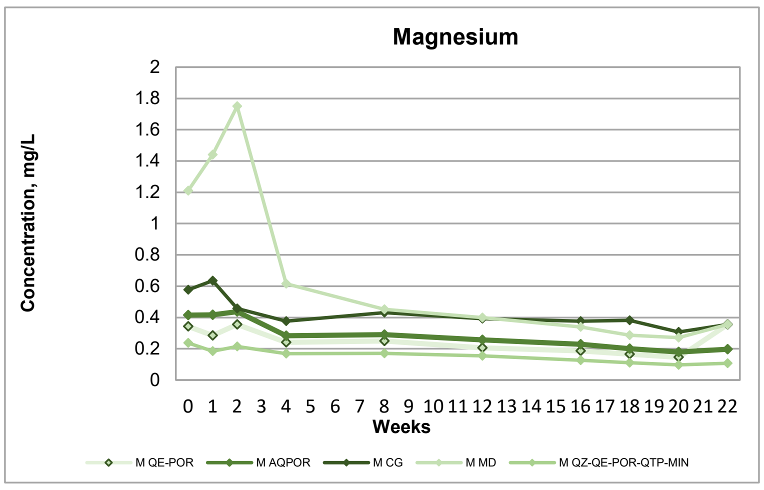


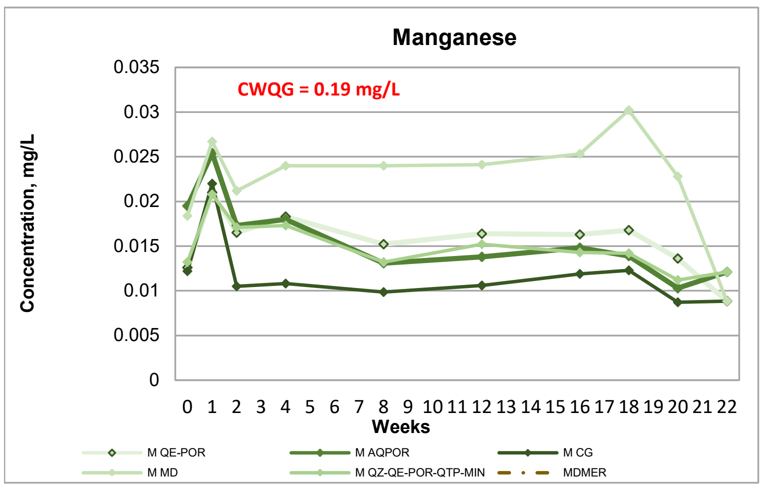


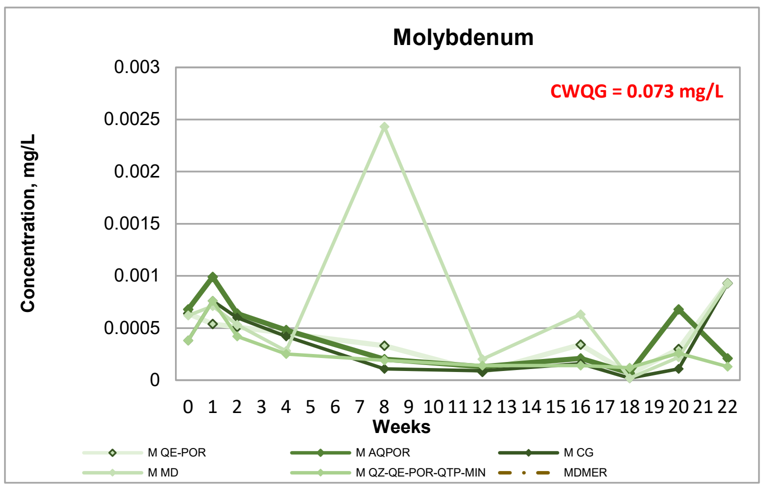






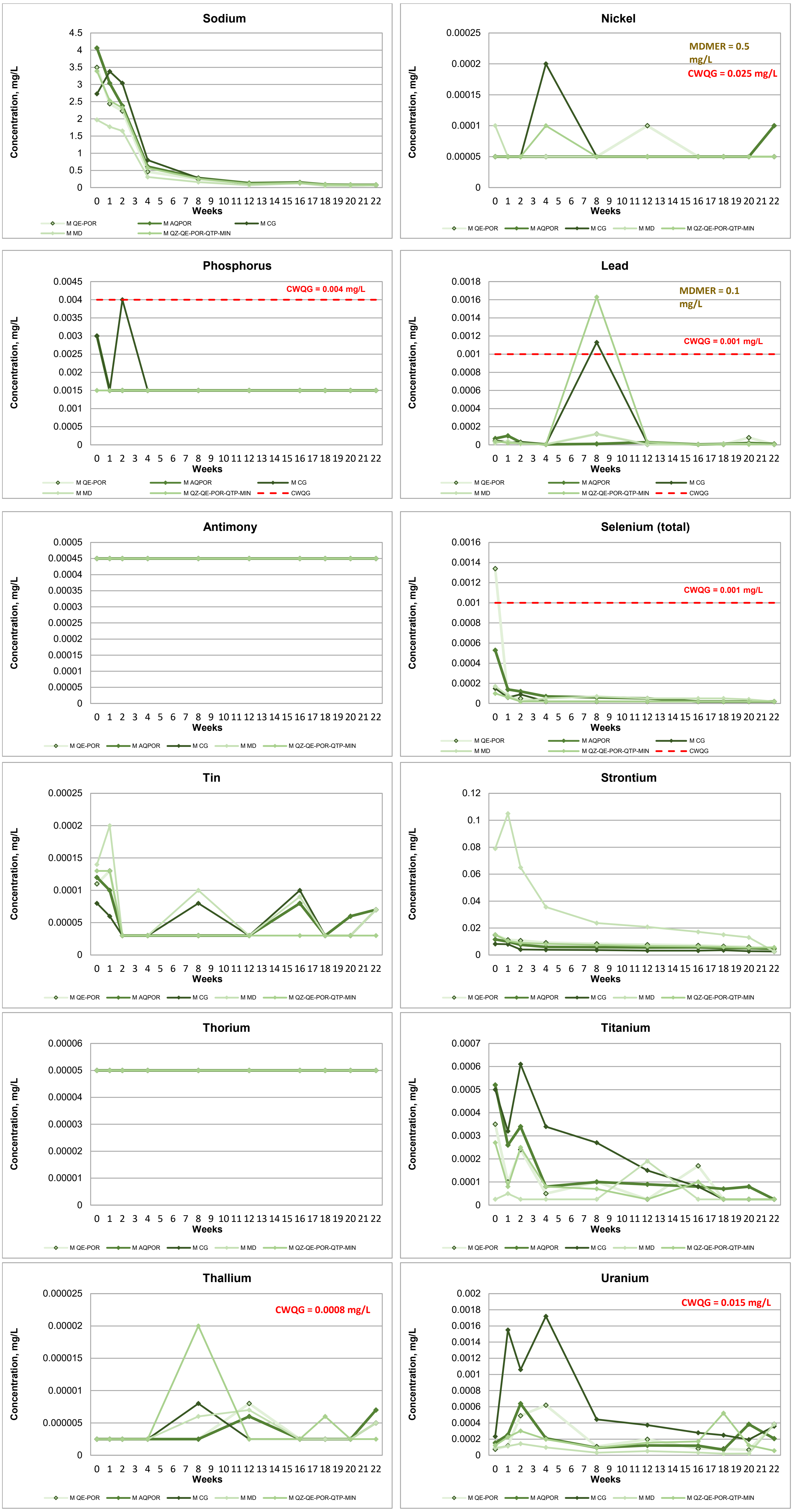






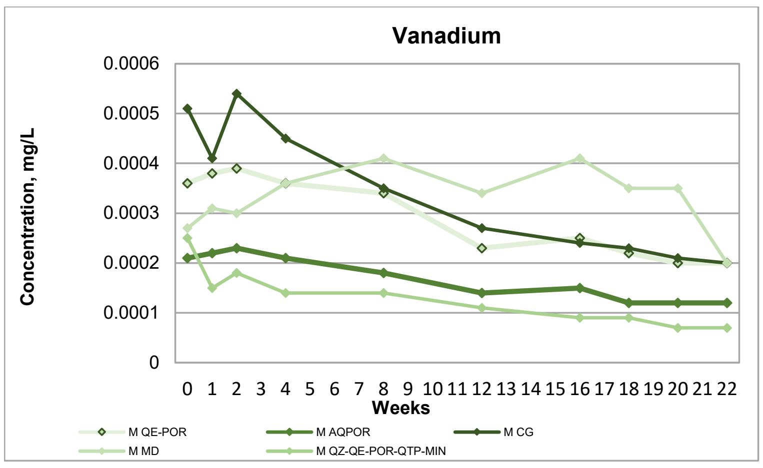
Note: Values below the respective detection limits (DLs) are shown as half DLs.

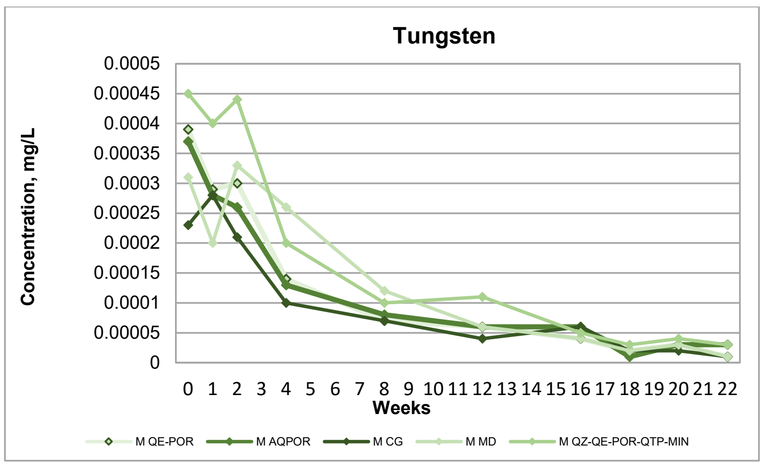
Marathon waste rock humidity cells

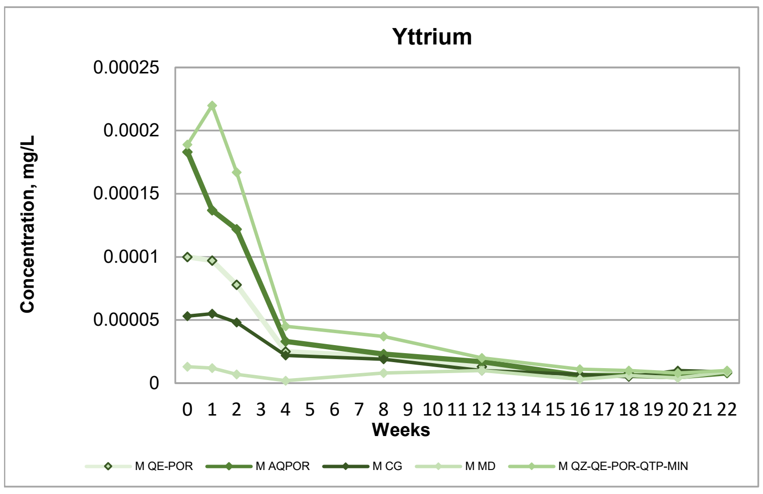


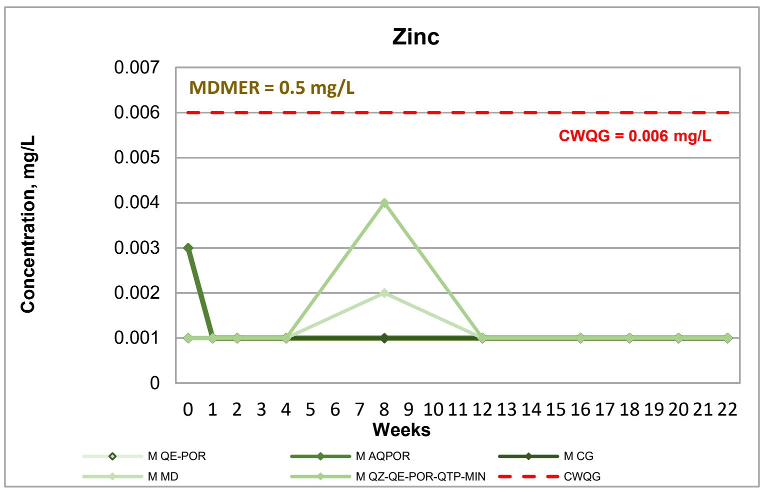
Note: Values below the respective detection limits (DLs) are shown as half DLs.

Marathon waste rock humidity cells



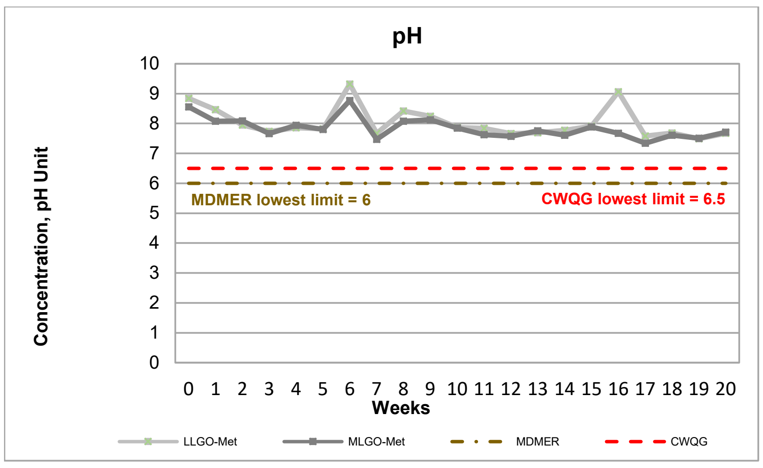


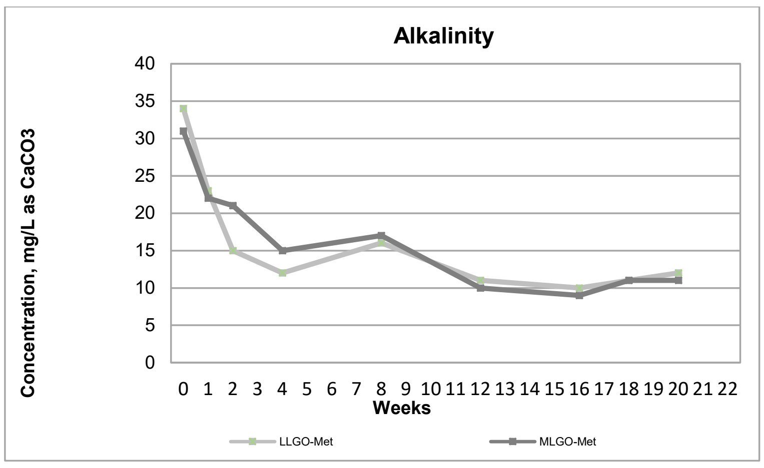


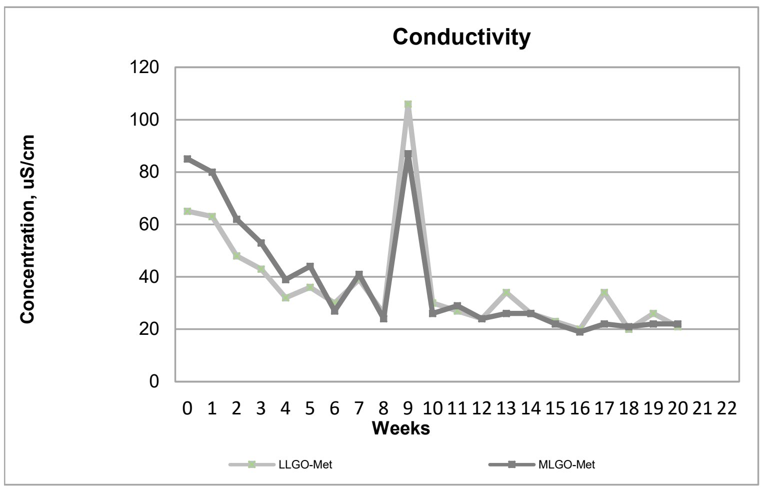


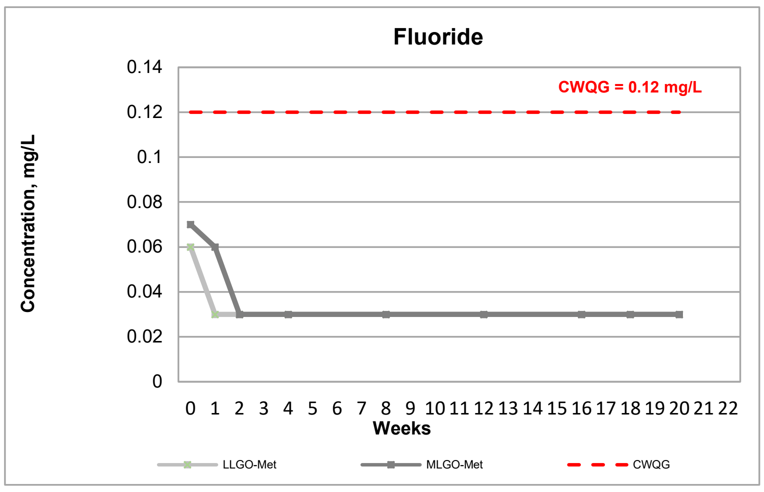
Note: Values below the respective detection limits (DLs) are shown as half DLs.

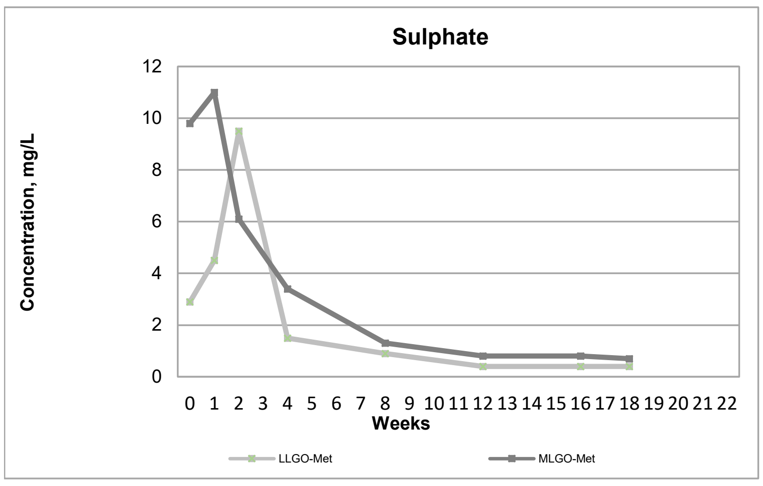
Marathon and Leprechaun low grade ore humidity cells

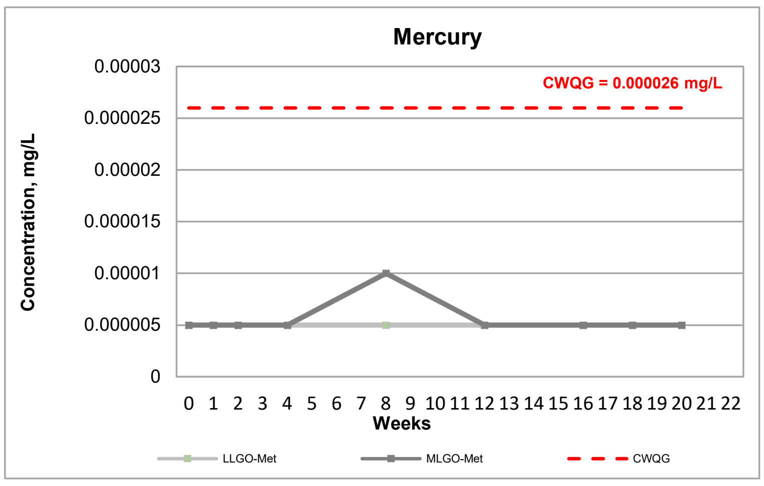


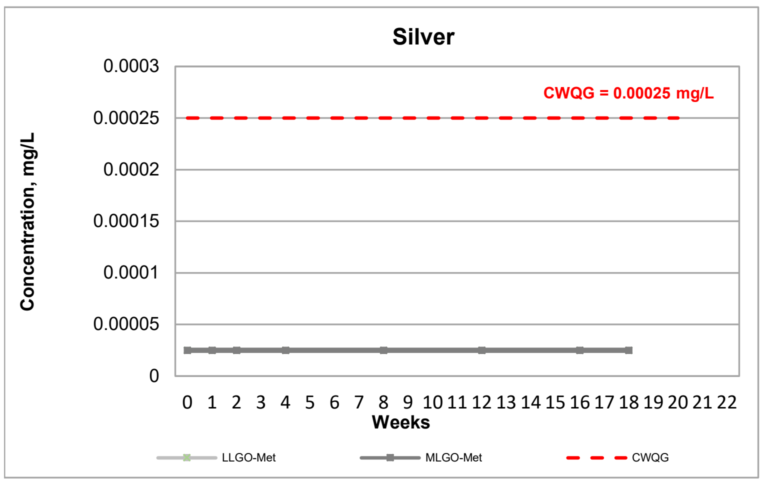


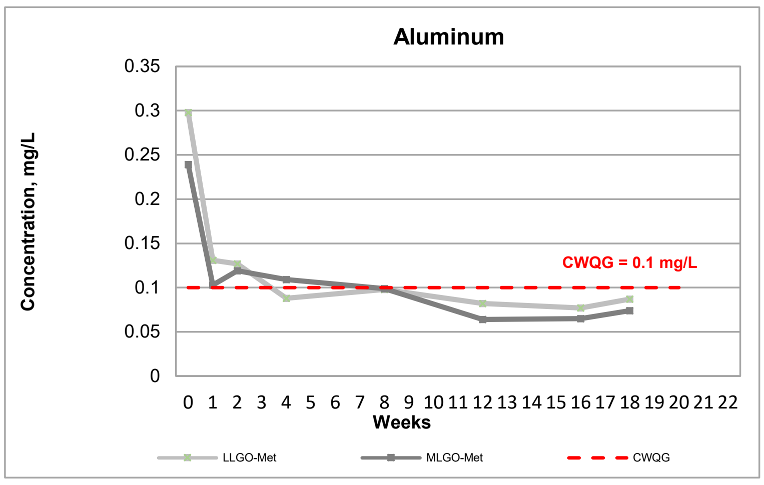


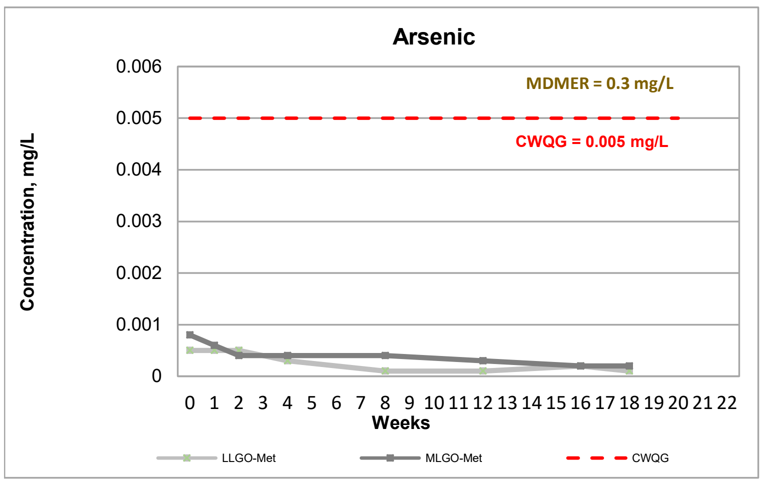


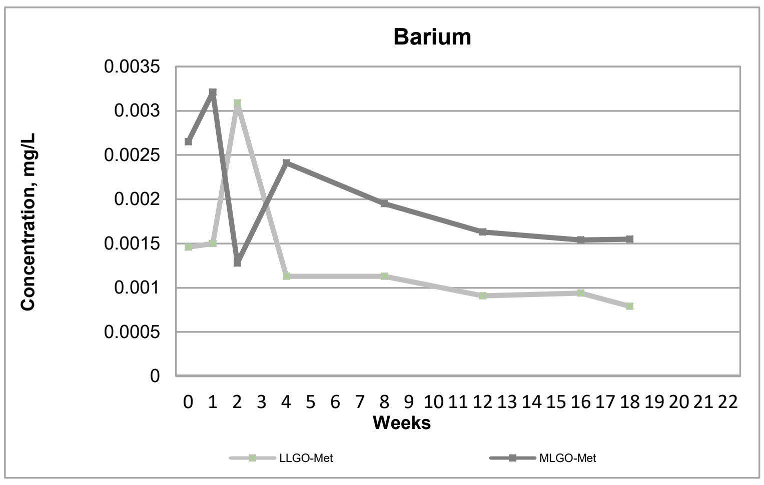


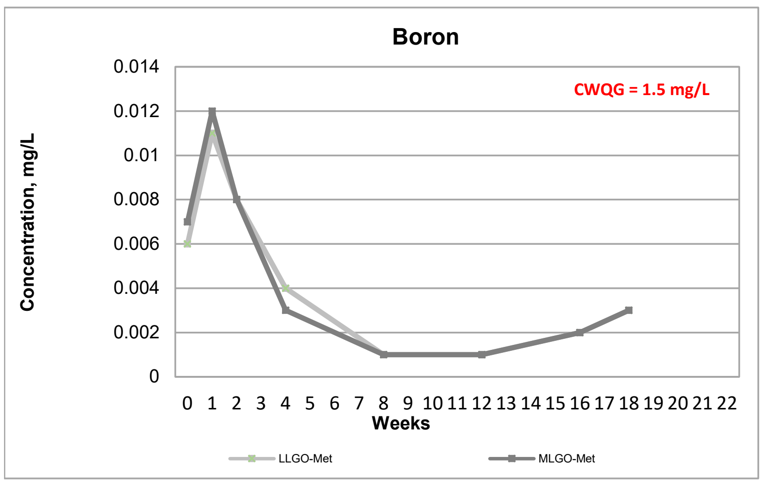


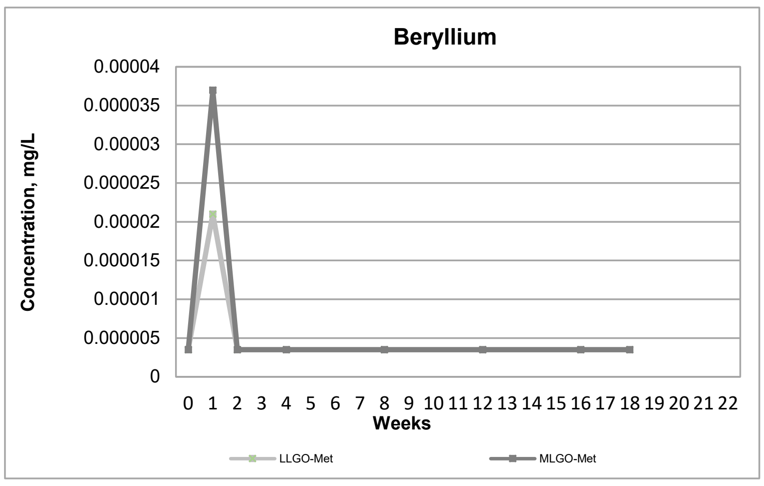






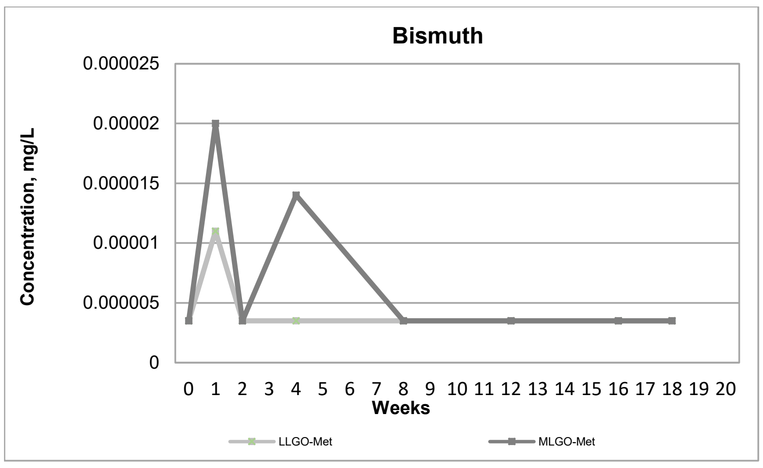


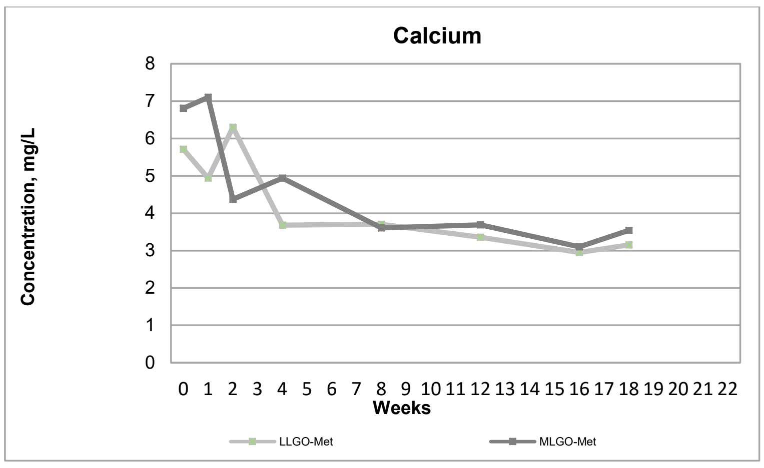


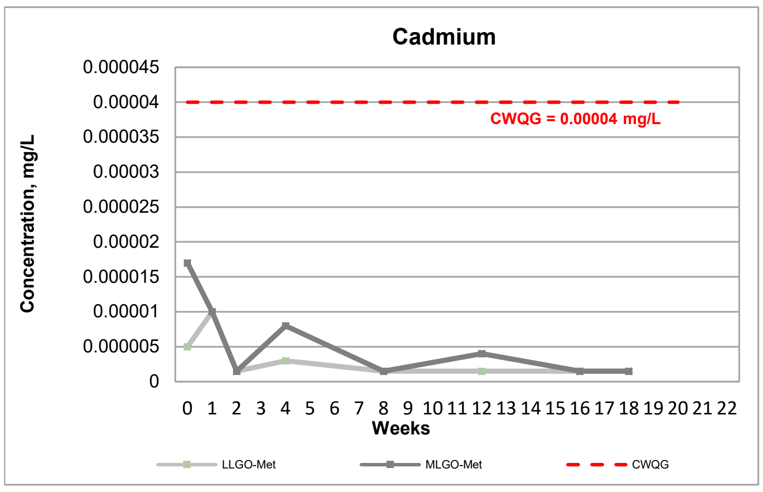


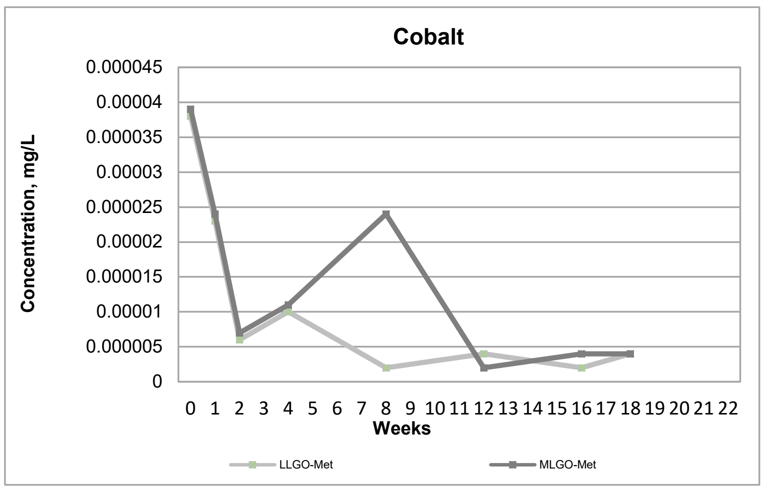
Note: Values below the respective detection limits (DLs) are shown as half DLs.

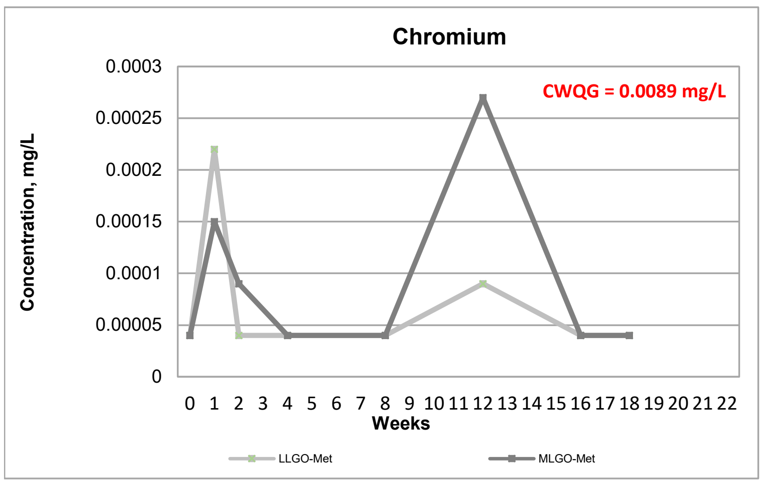
Marathon and Leprechaun low grade ore humidity cells

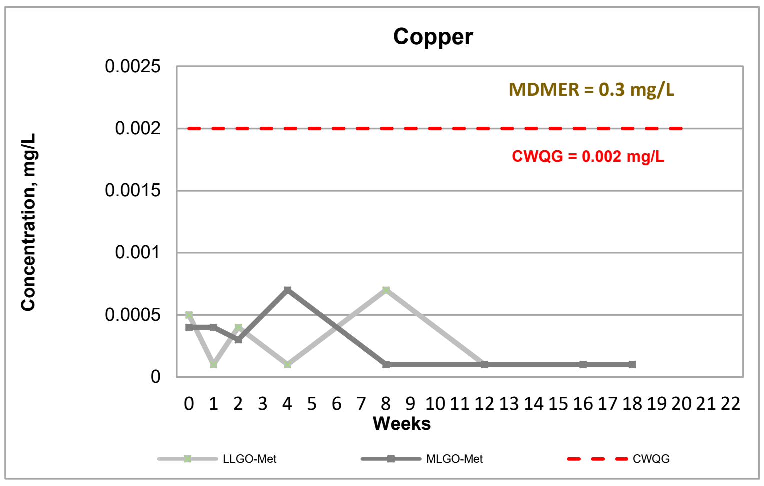


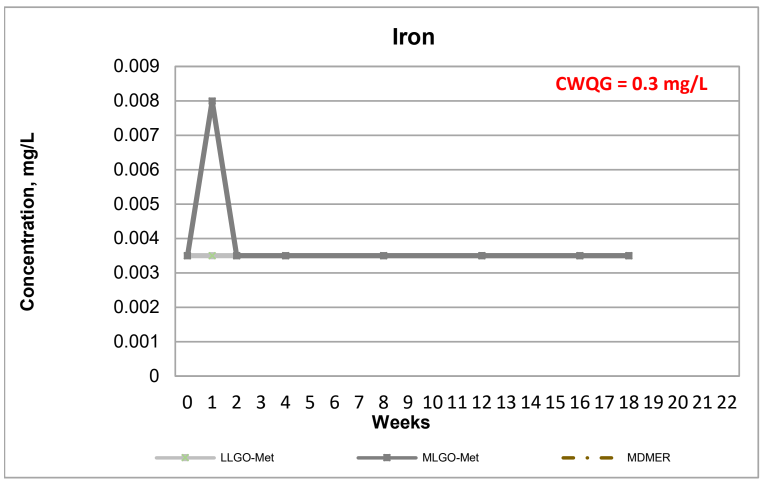


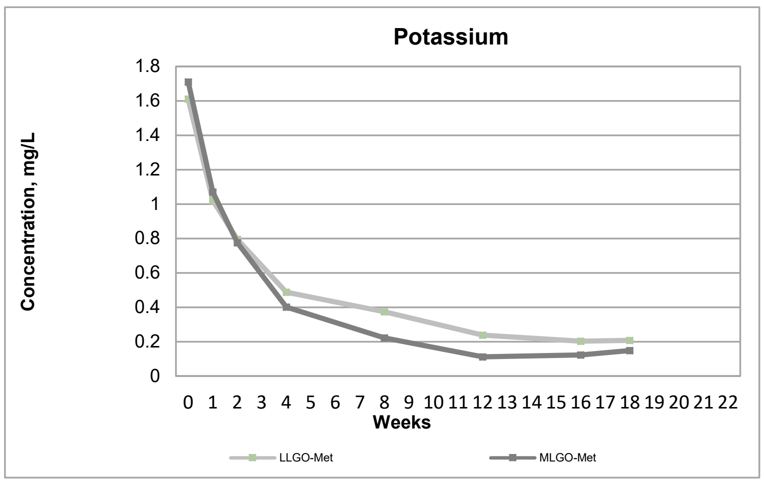


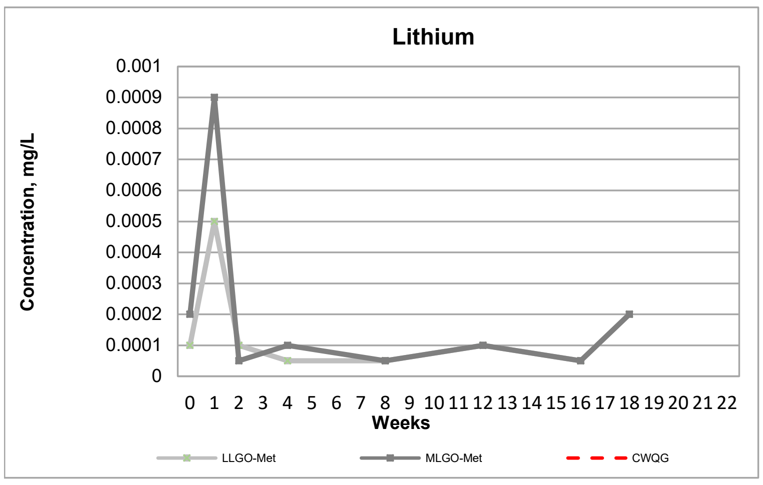


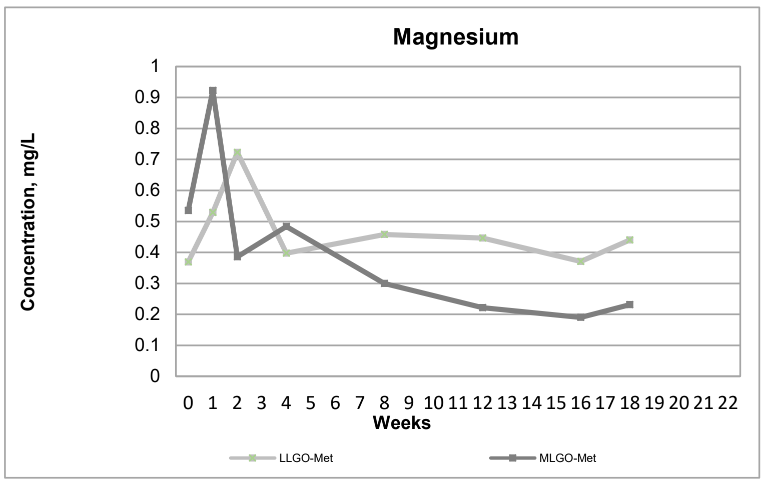


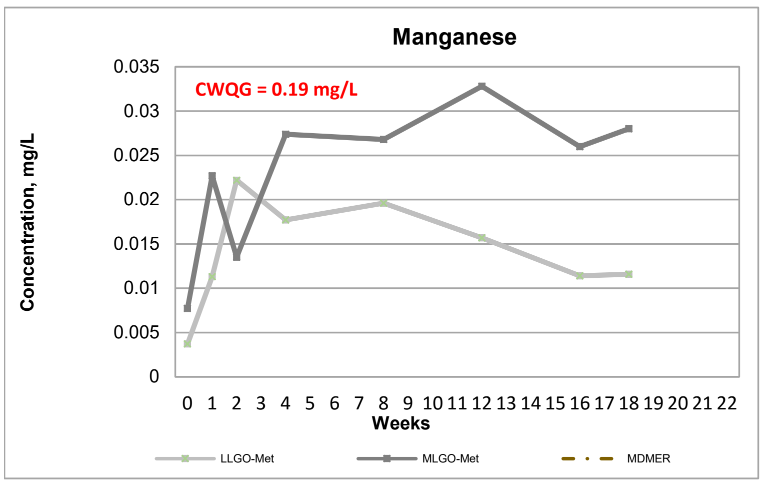


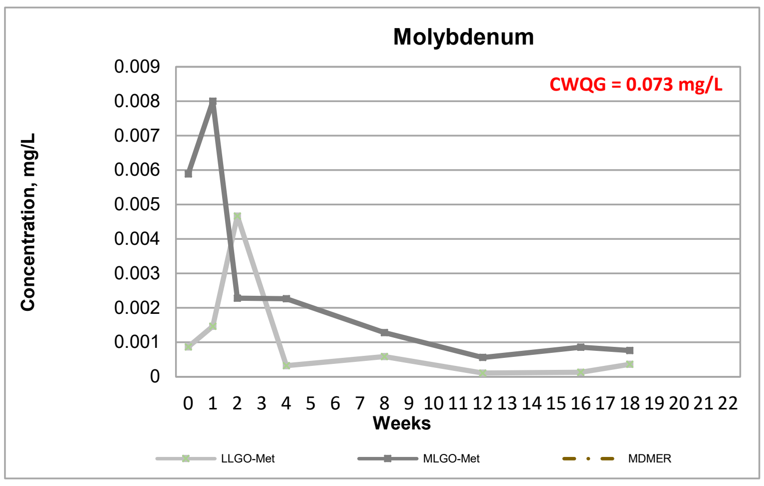












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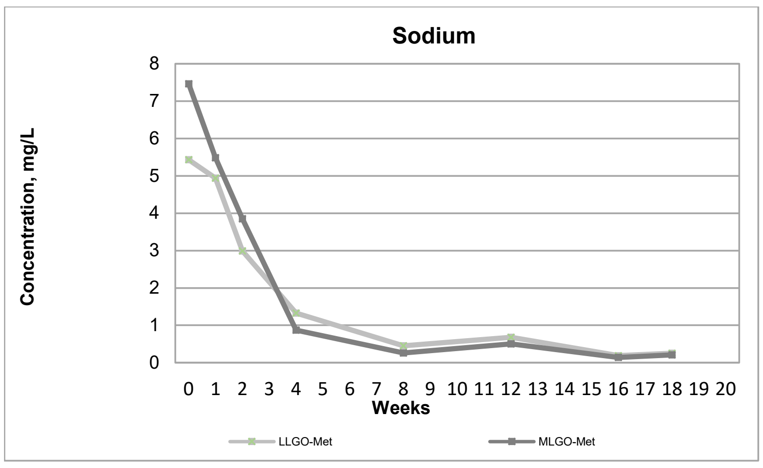
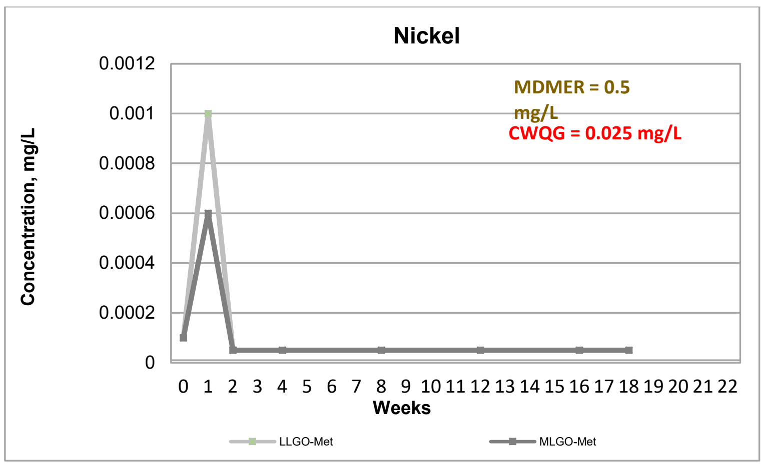
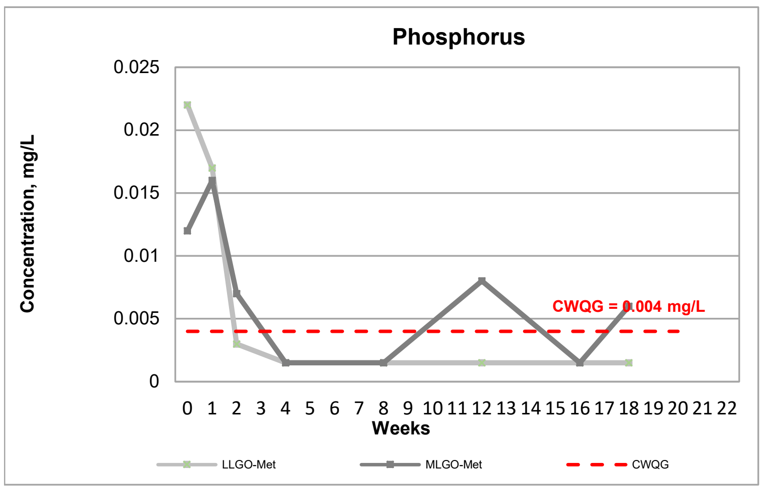
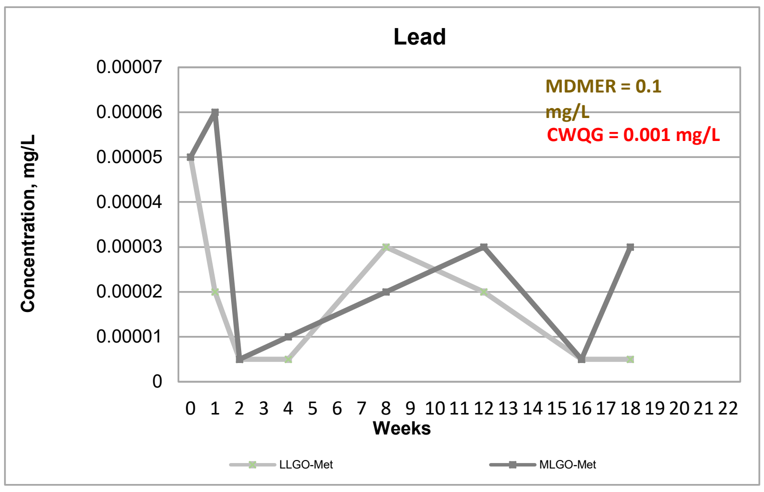
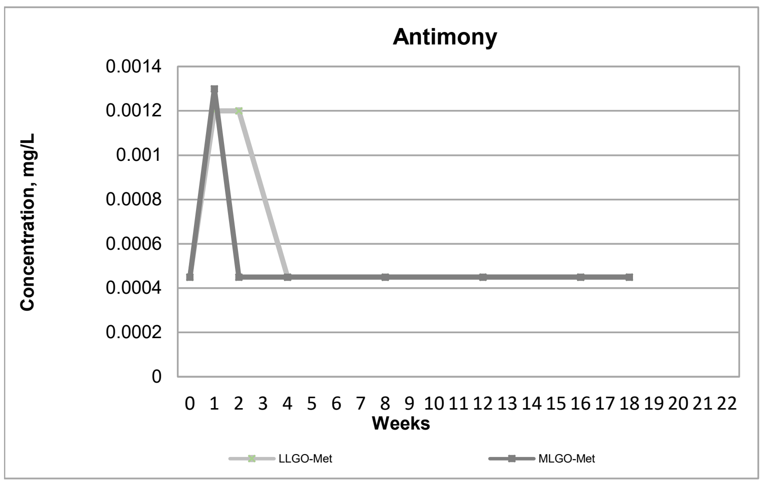
Marathon and Leprechaun low grade ore humidity cells

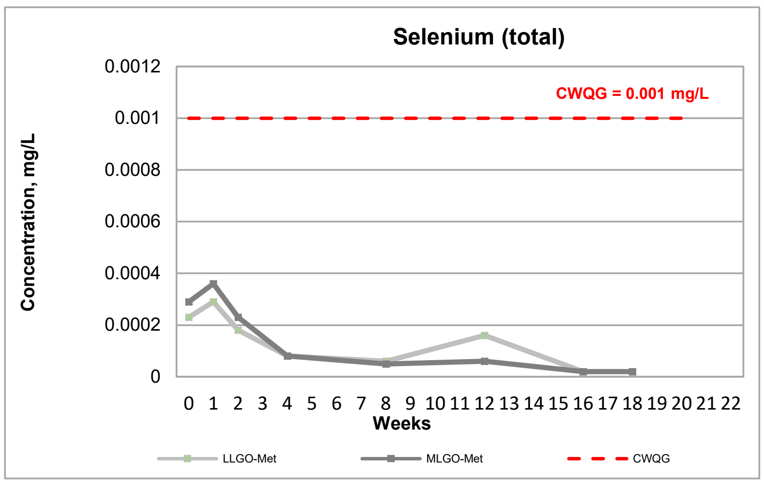


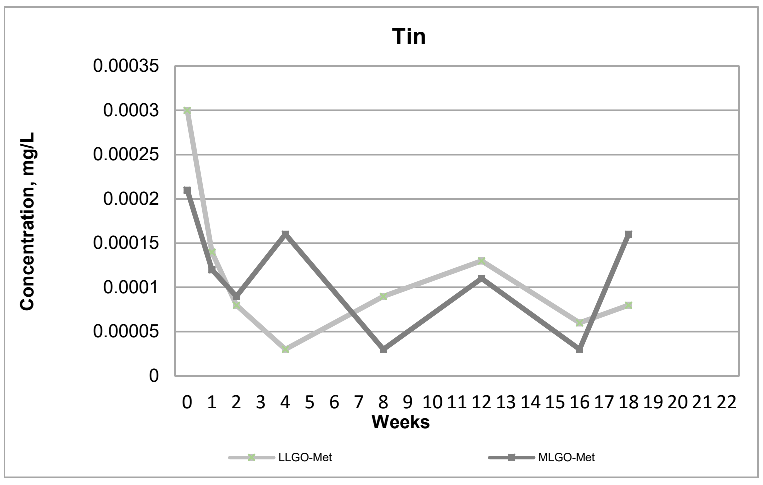


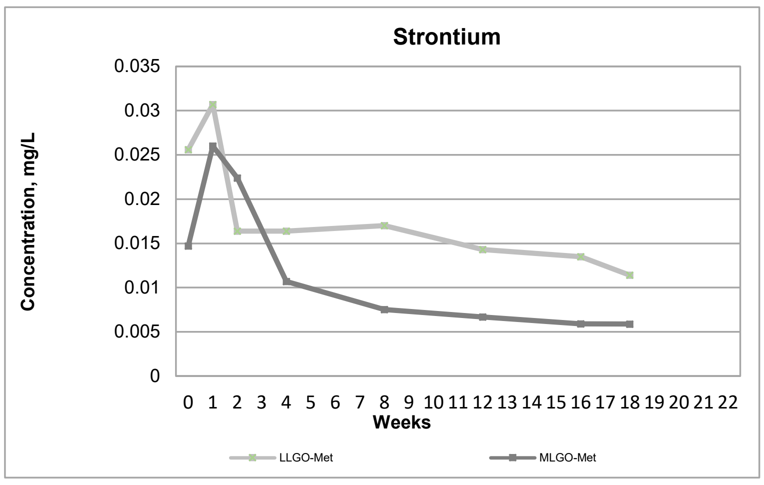


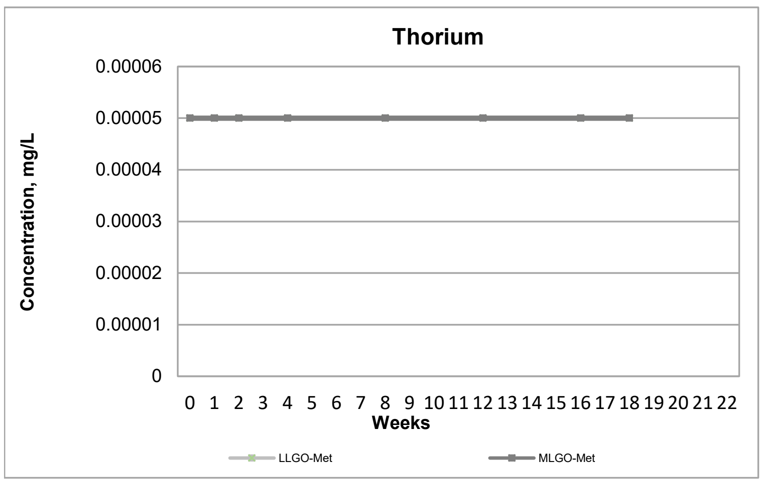


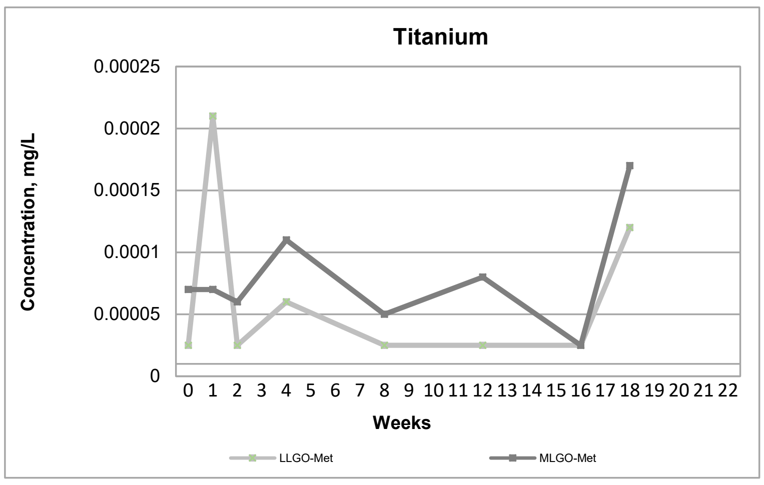


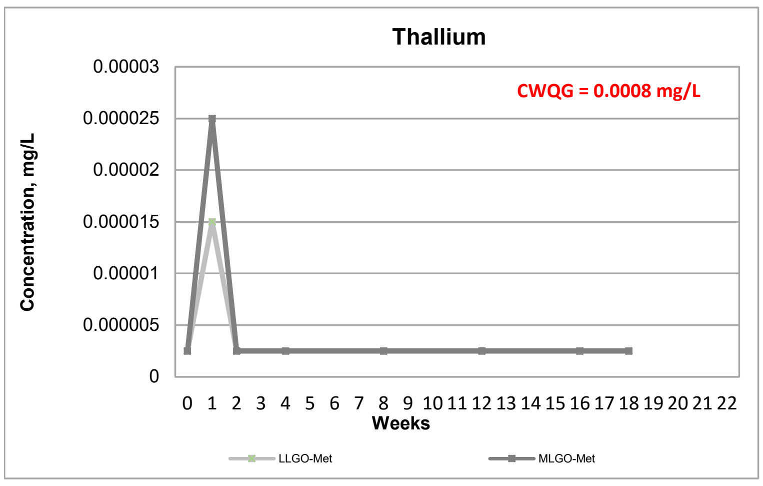


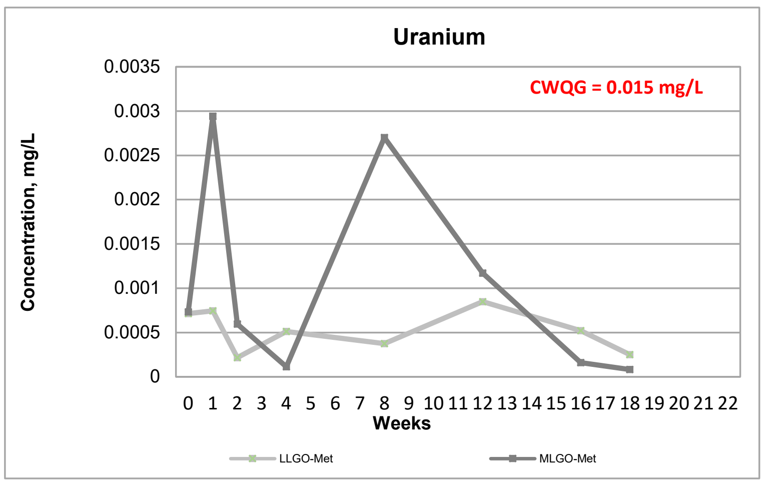












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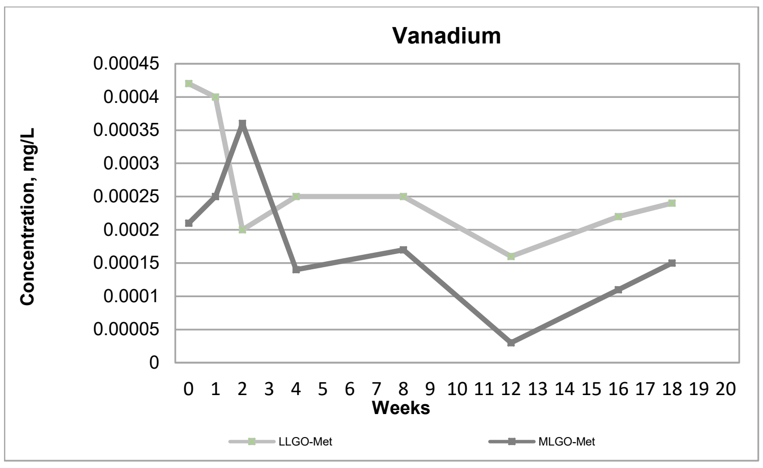
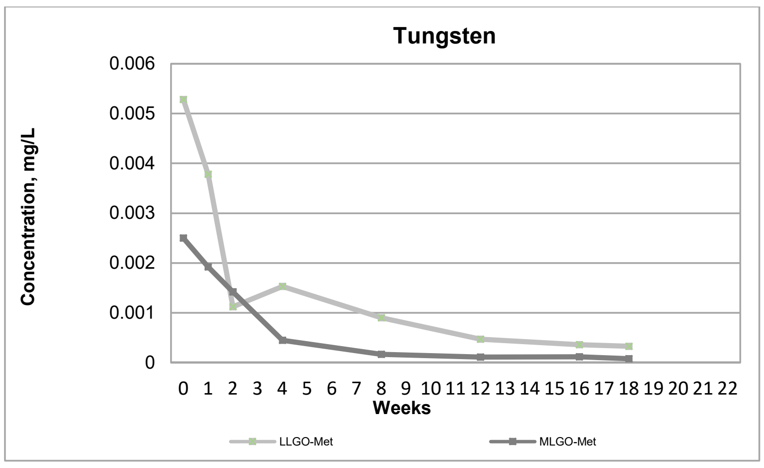
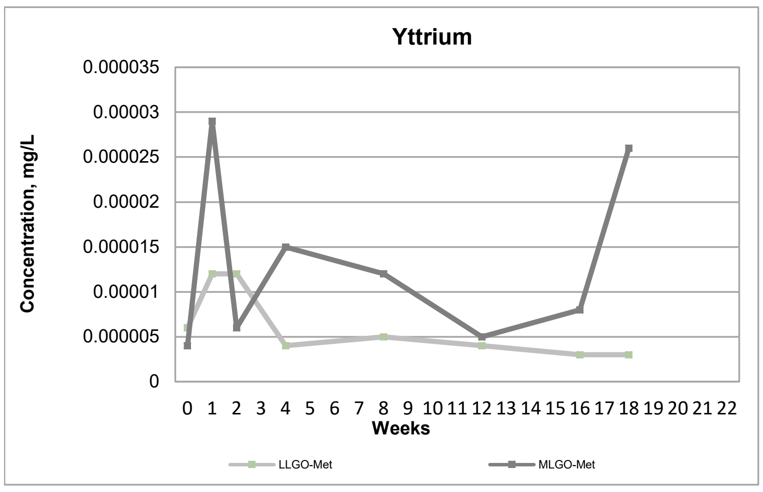
Marathon and Leprechaun low grade ore humidity cells



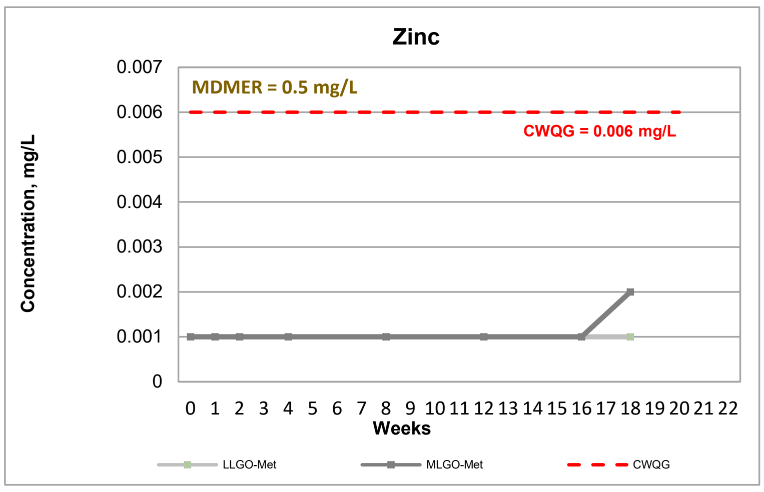
Vanadium



Tungsten



Yttrium



Zinc

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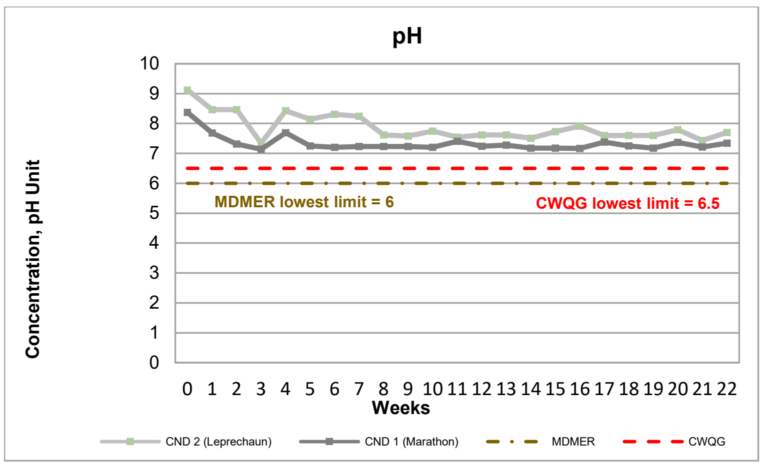
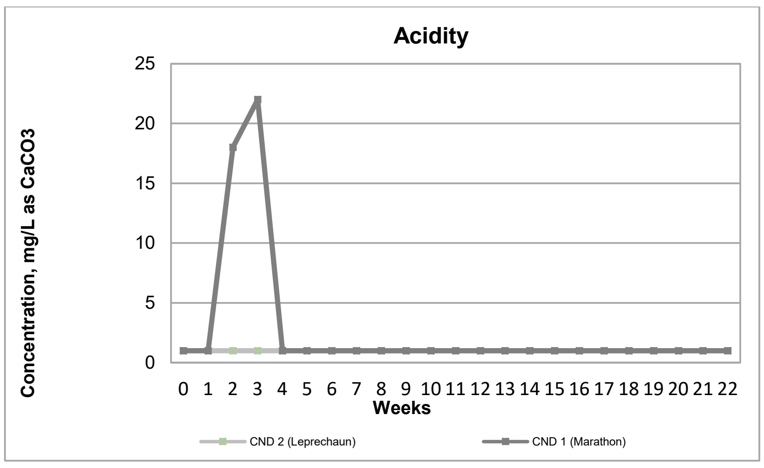
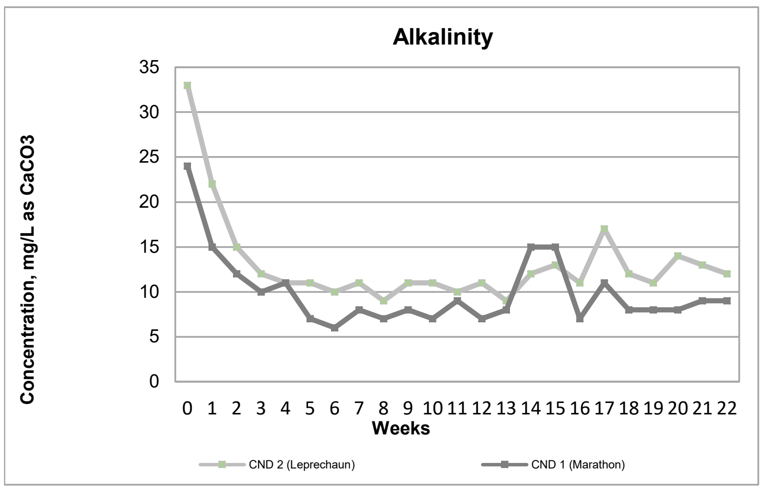
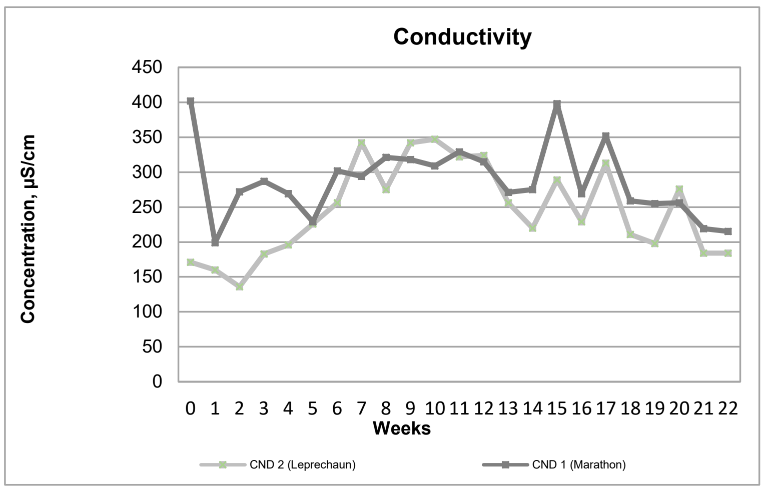
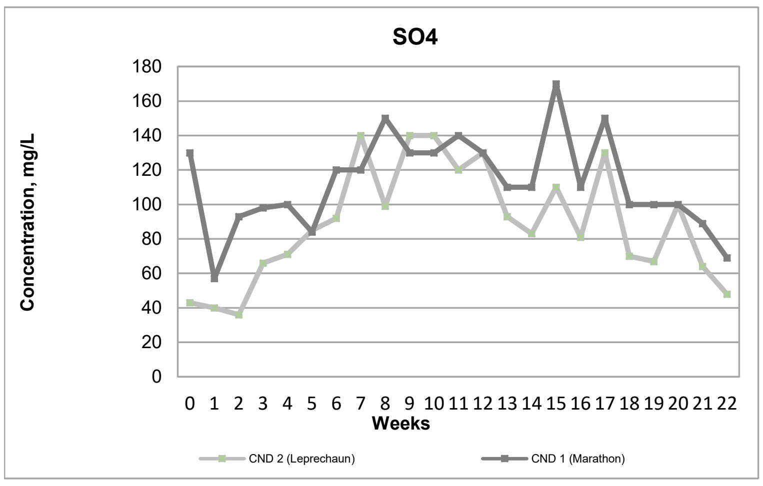
Marathon and Leprechaun tailings humidity cells

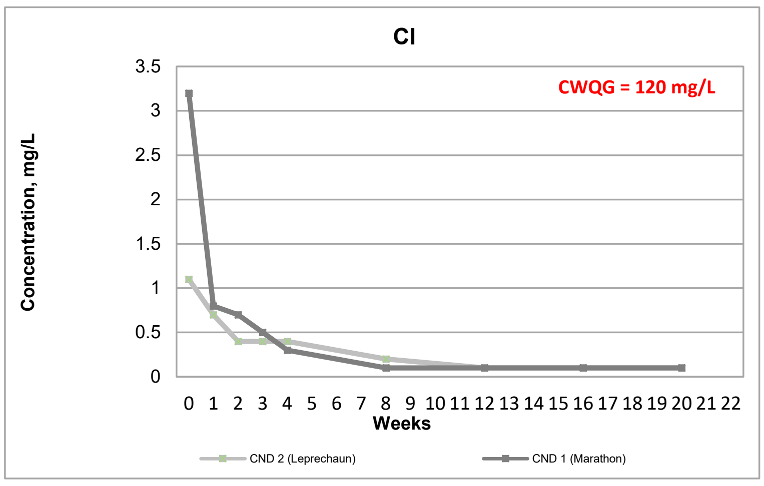


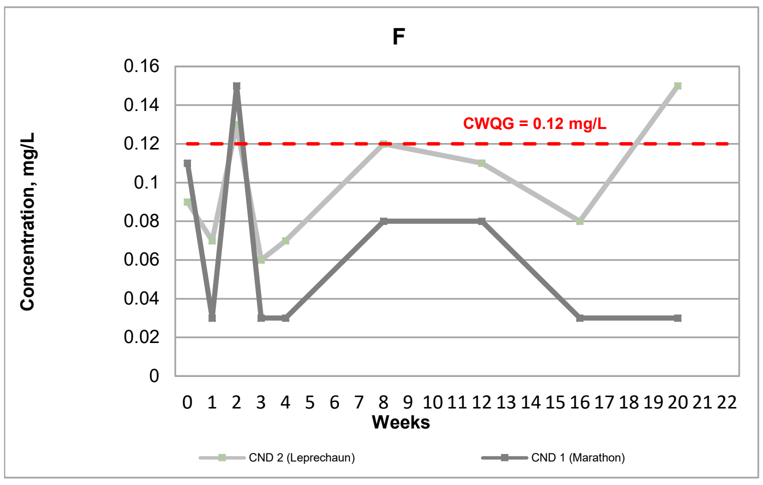


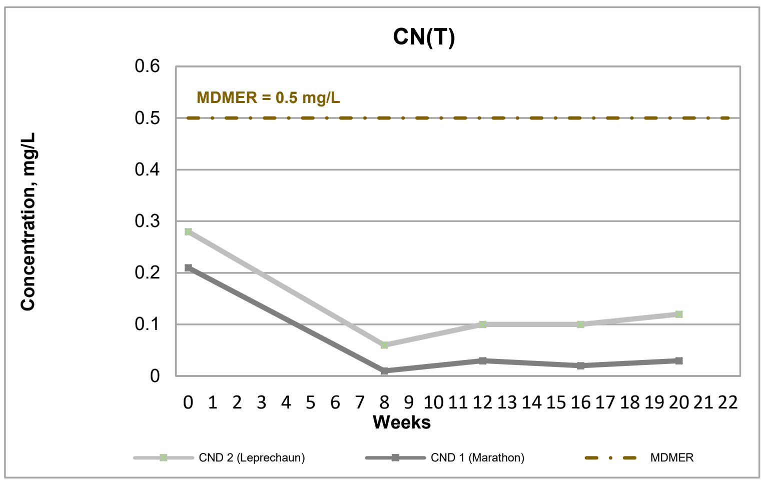


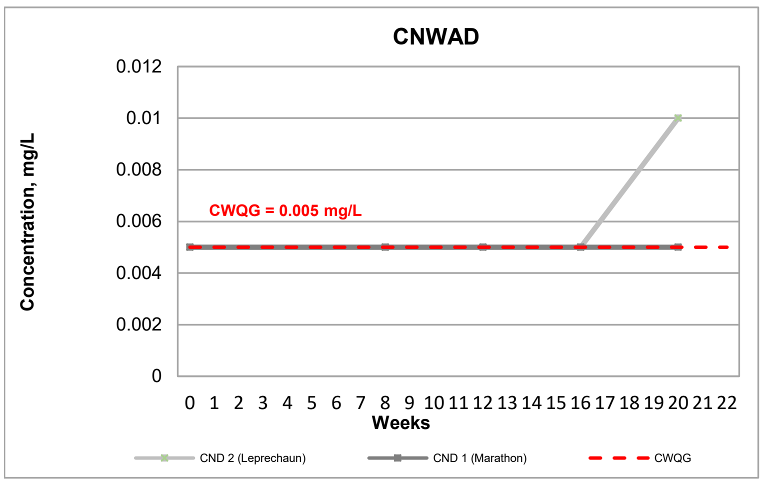


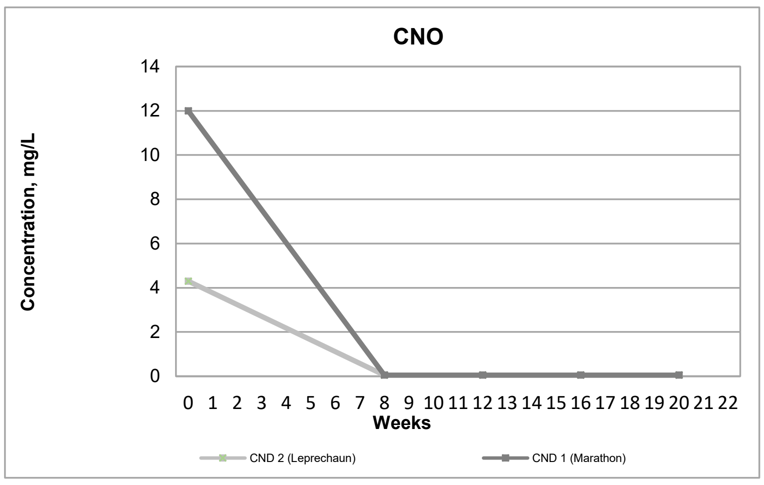


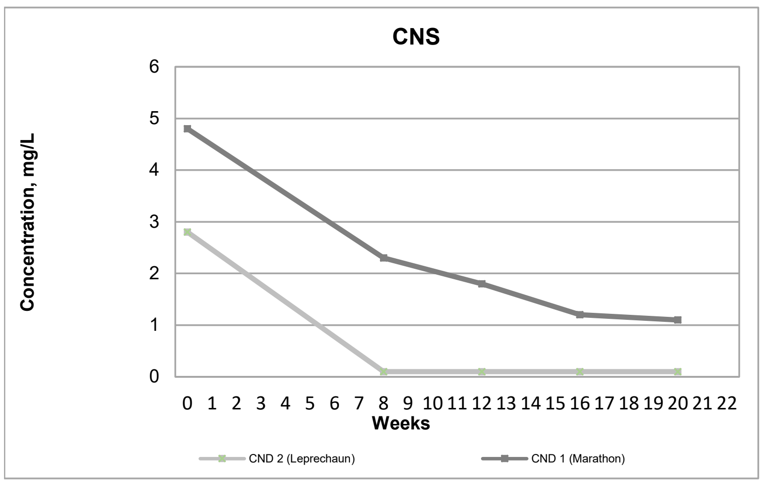


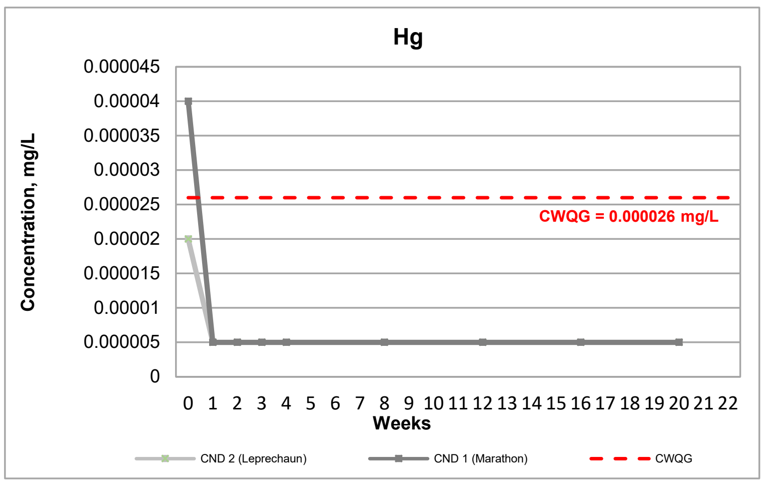






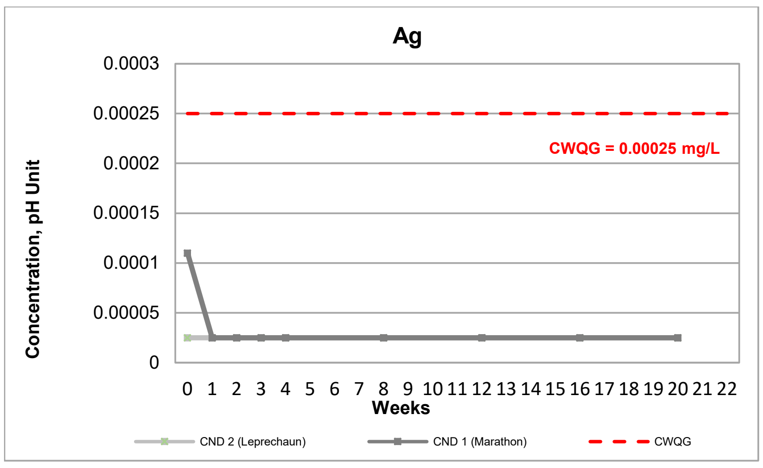


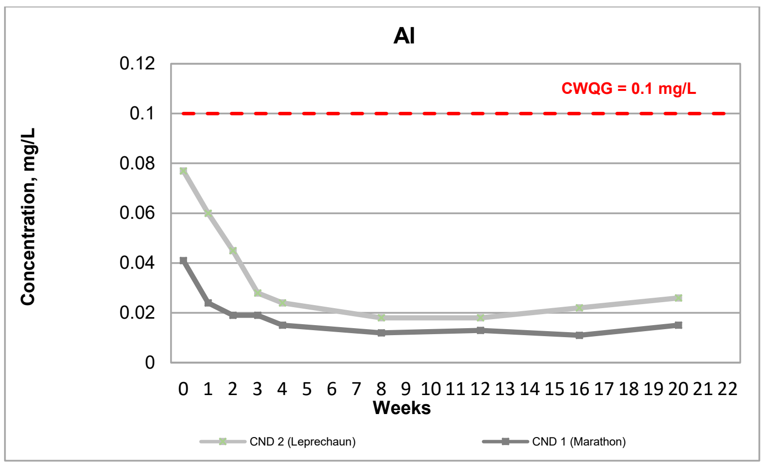


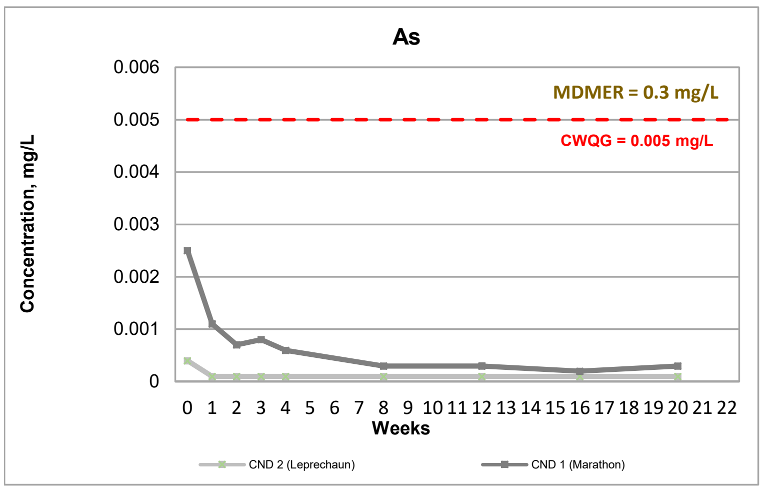


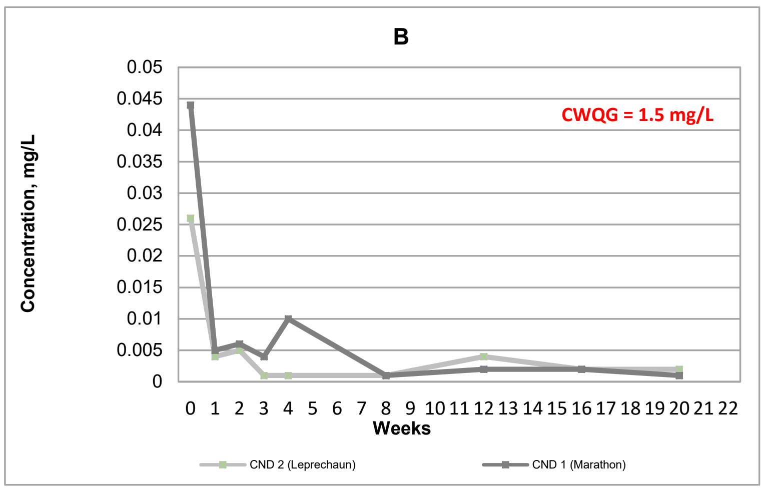
Note: Values below the respective detection limits (DLs) are shown as half DLs. CNWAD - weak acid dissociable cyanide.

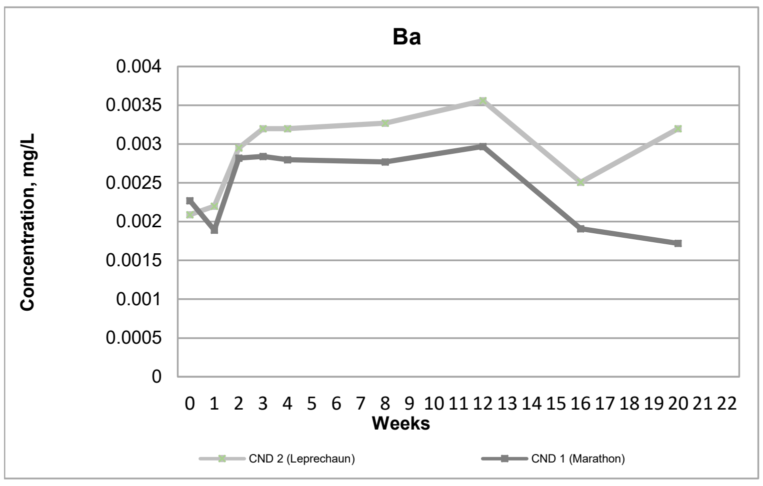
Marathon and Leprechaun tailings humidity cells

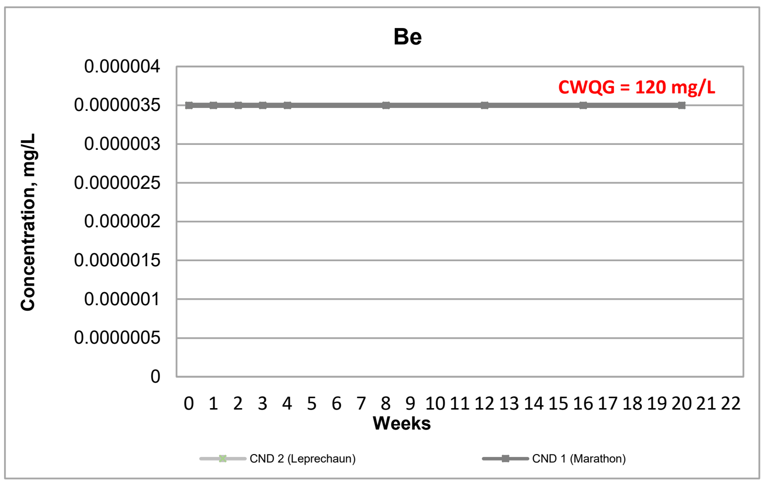


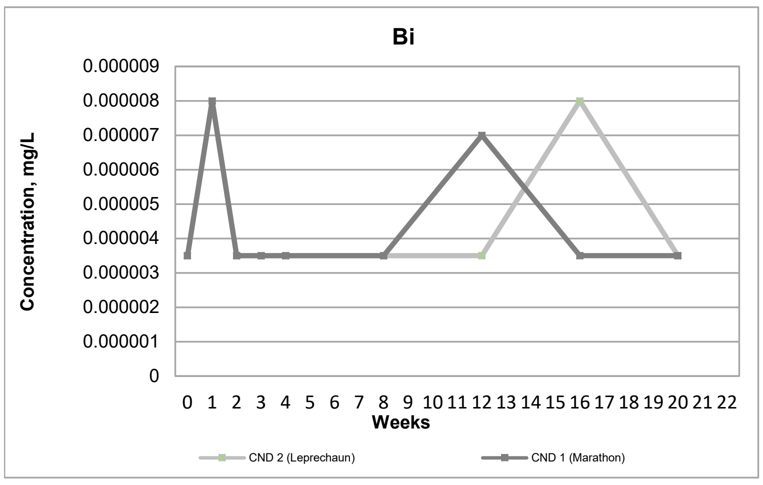


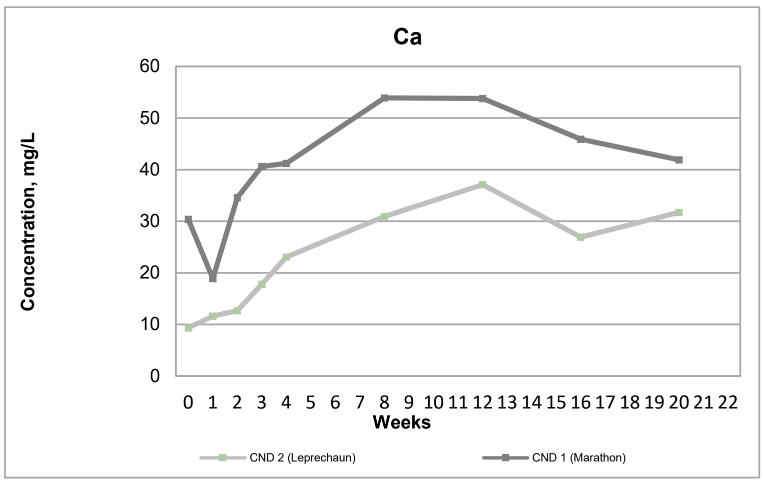


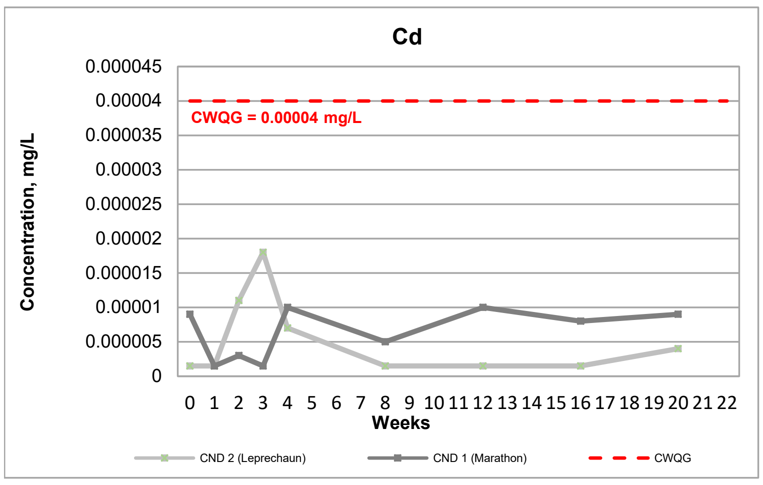


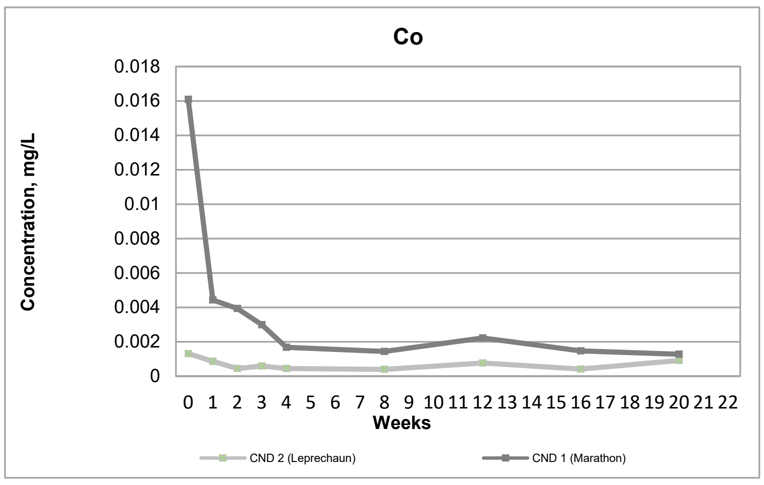


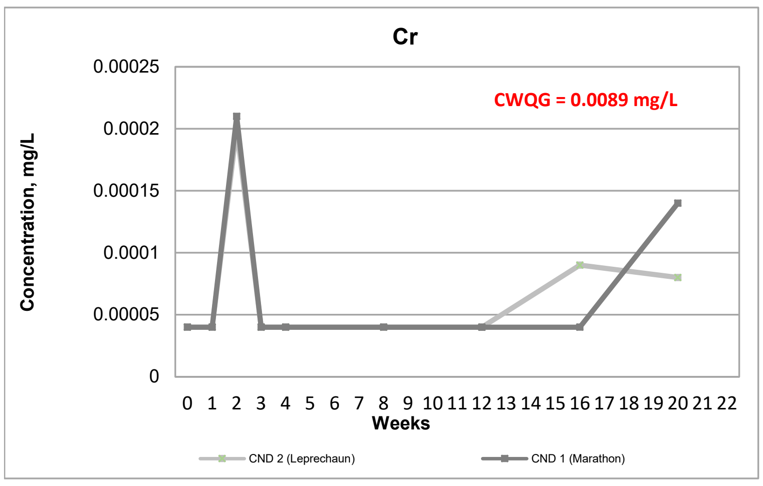


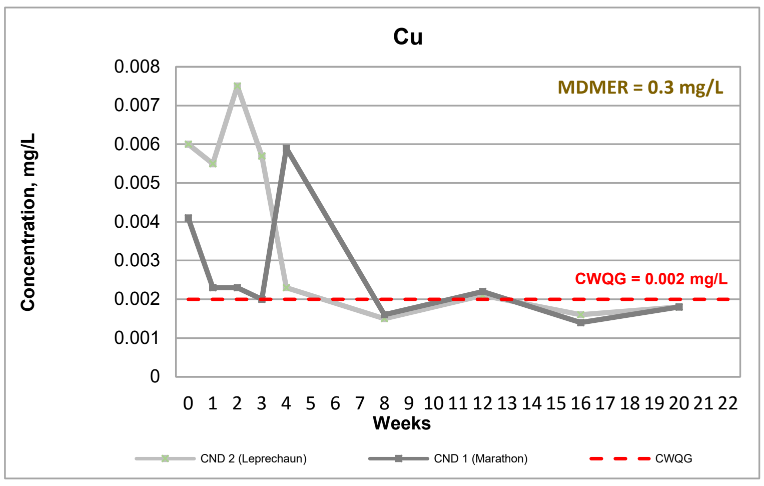






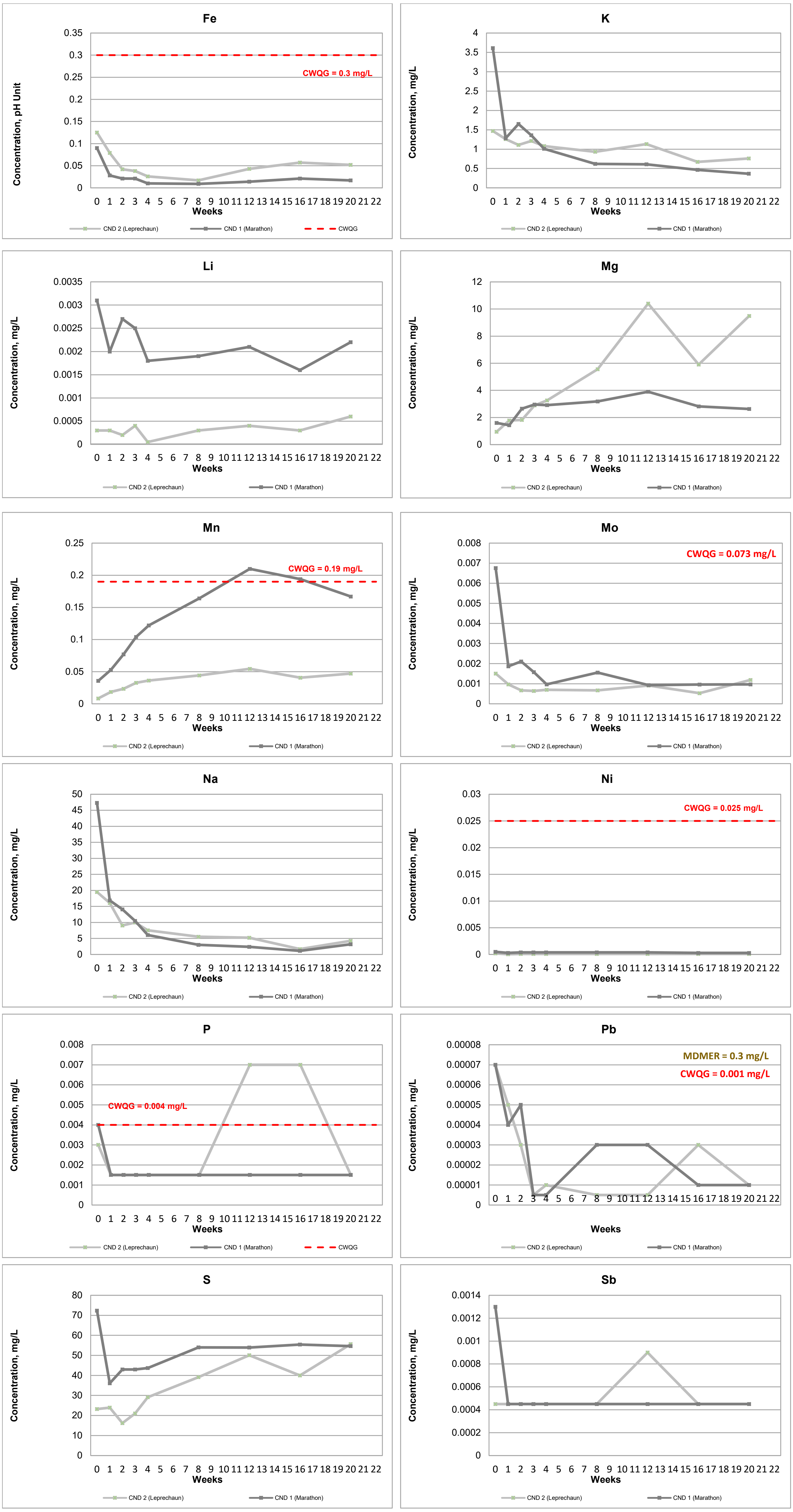






Note: Values below the respective detection limits (DLs) are shown as half DLs.

Marathon and Leprechaun tailings humidity cells



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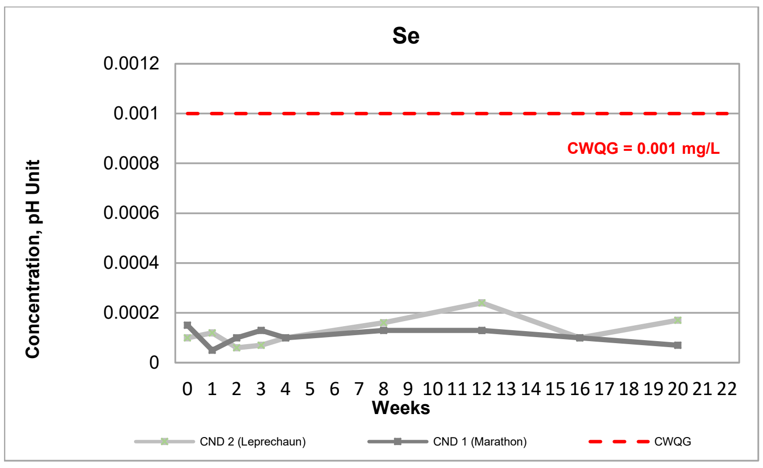
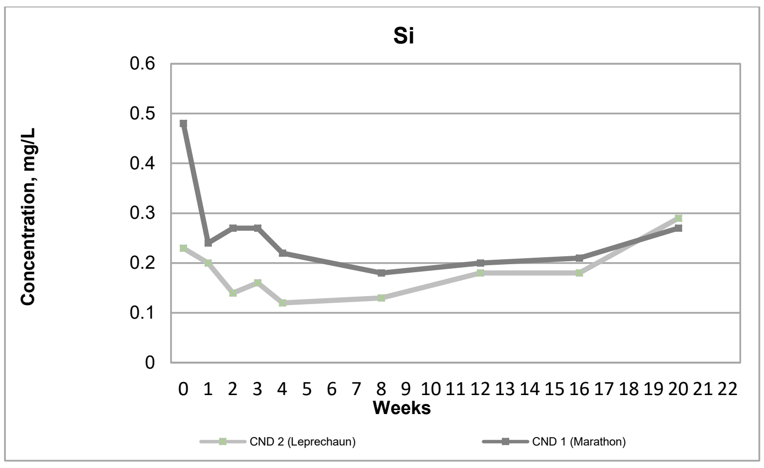
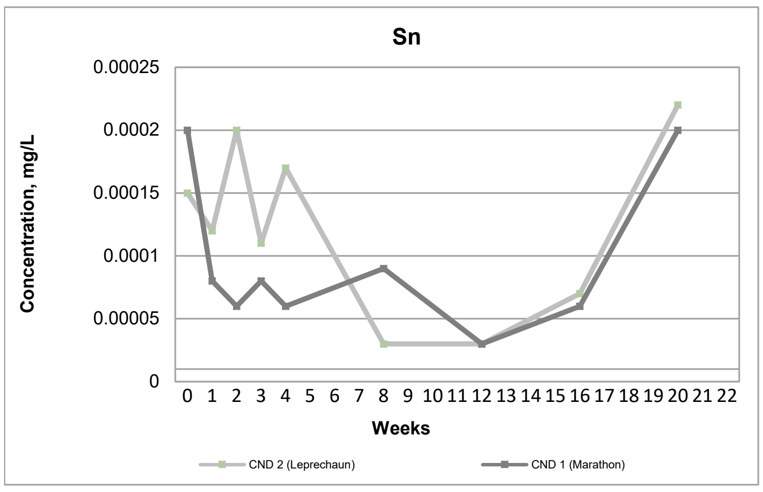
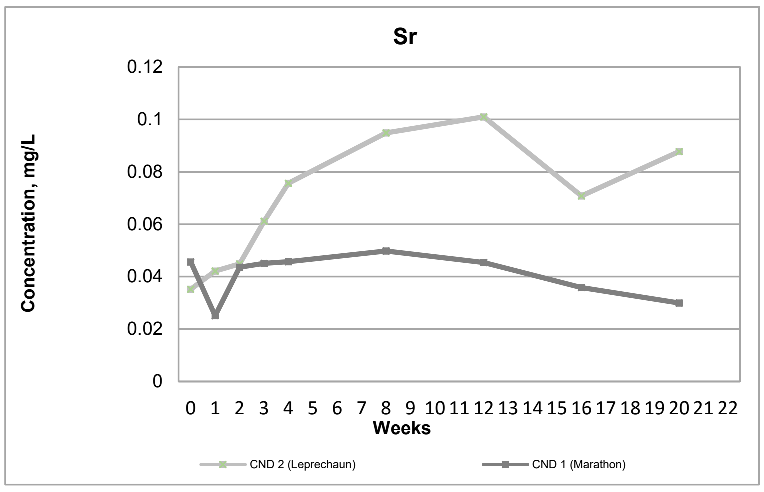
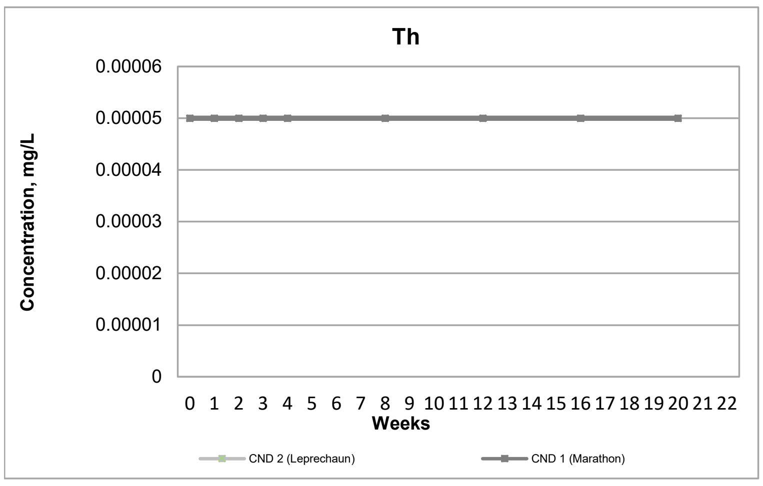
Marathon and Leprechaun tailings humidity cells

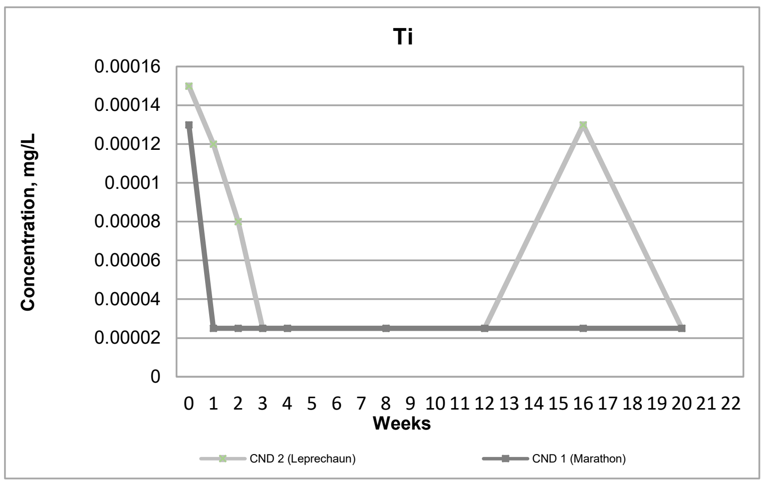


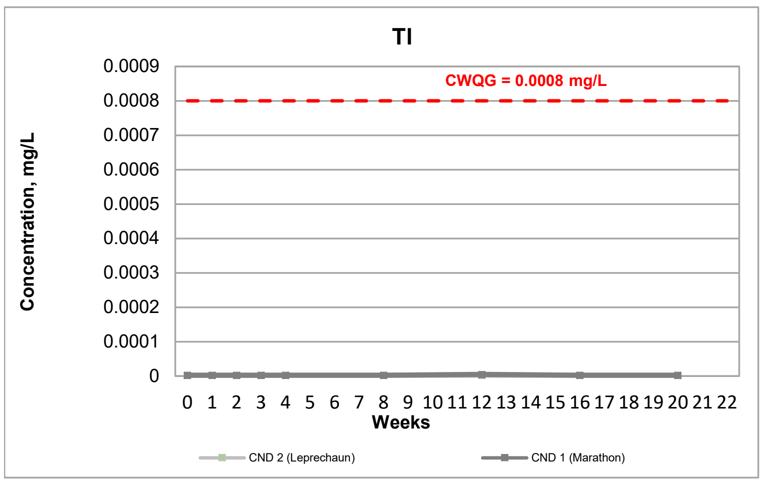


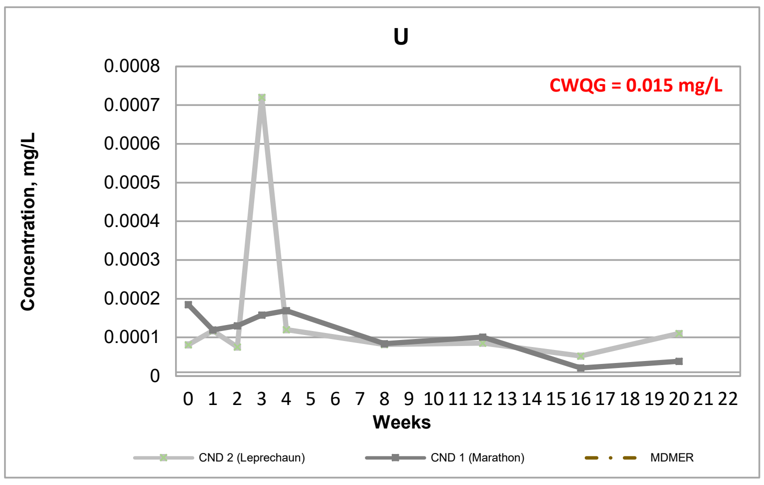


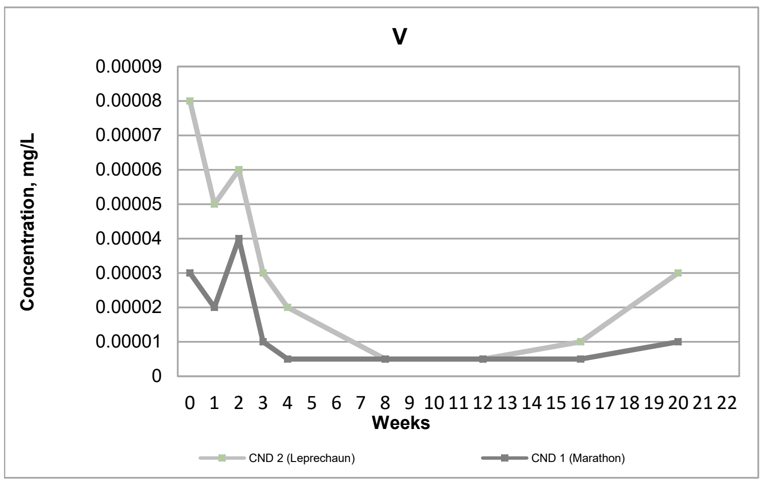


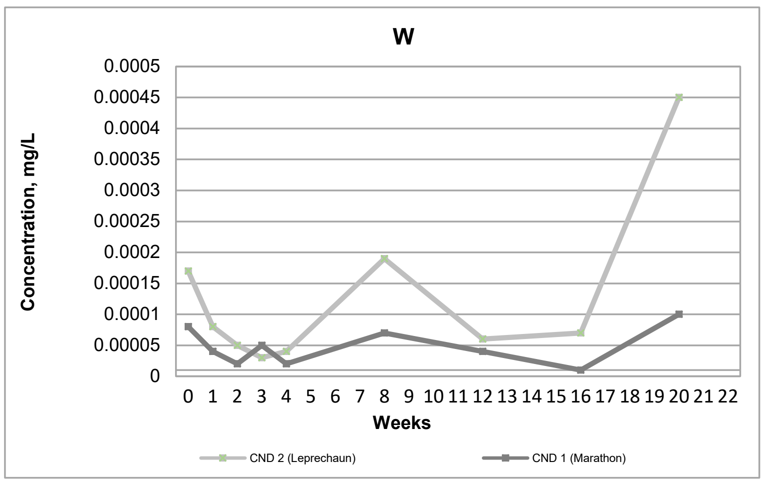


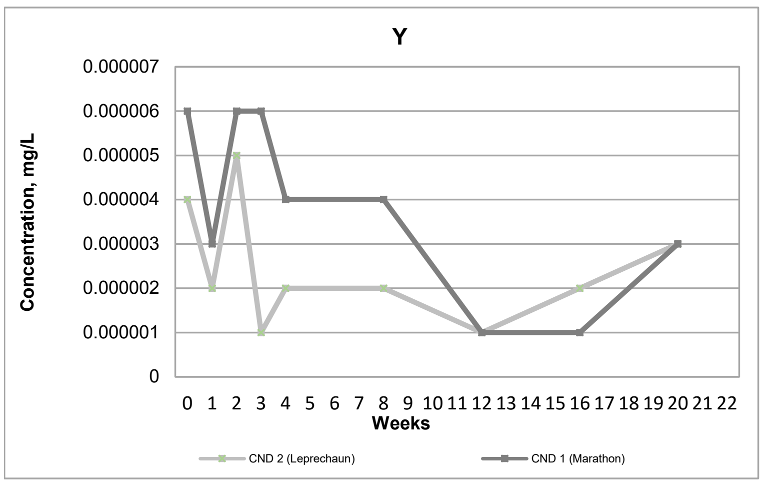


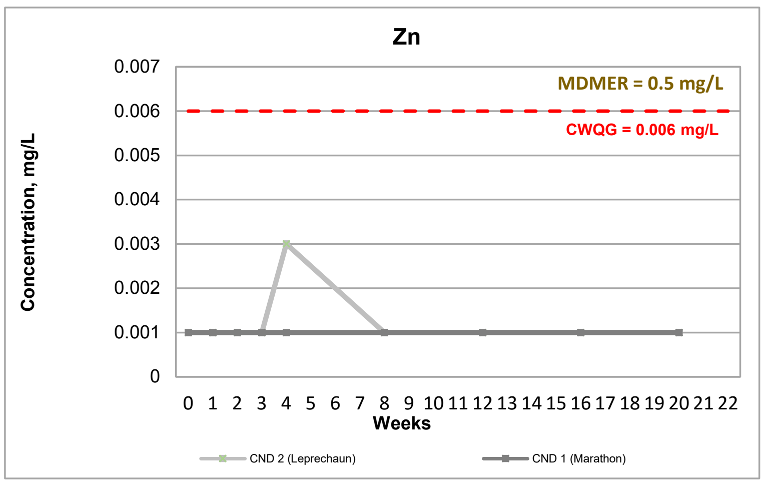




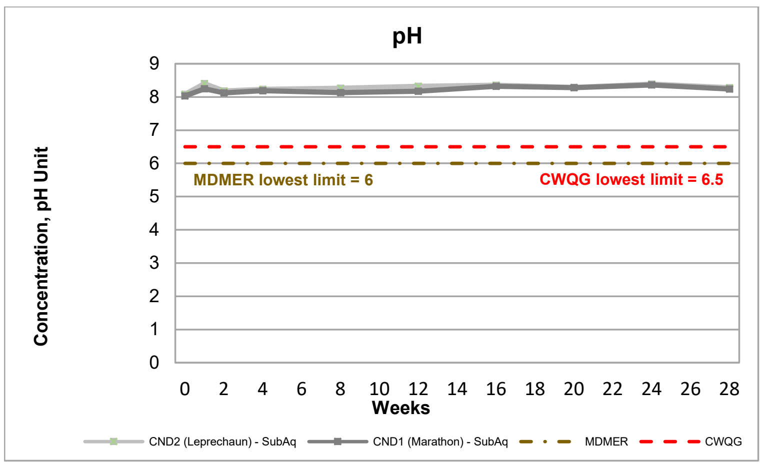


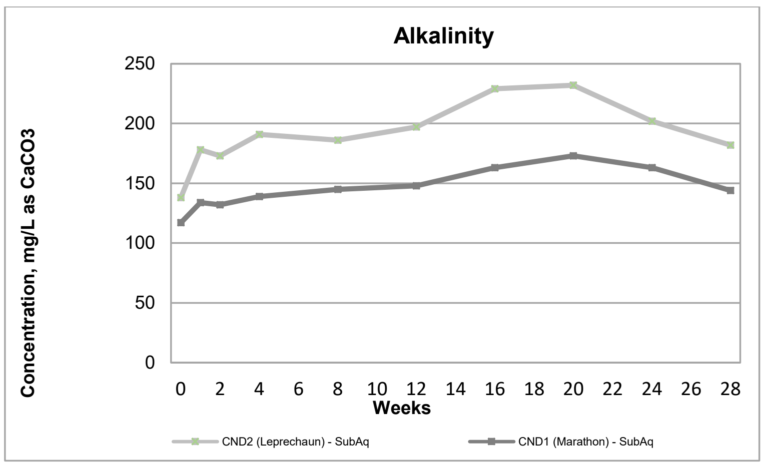


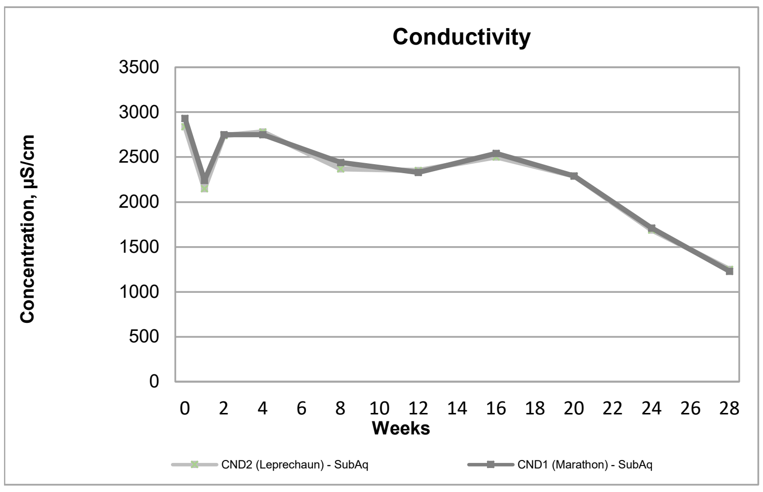


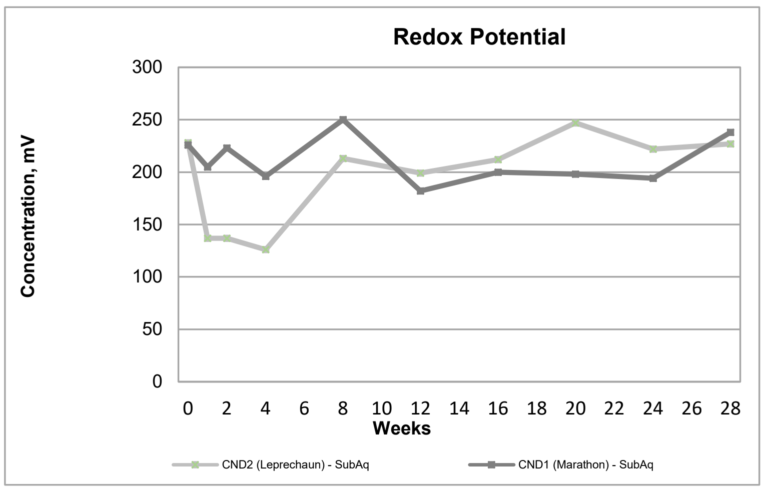


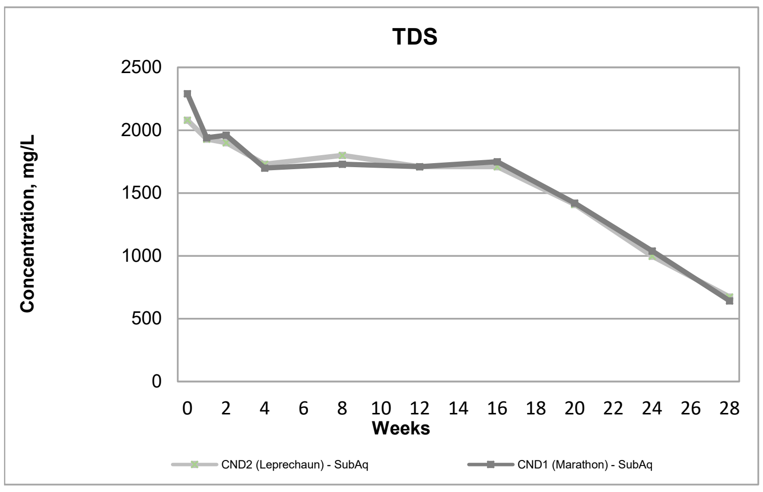
Note: Values below the respective detection limits (DLs) are shown as half DLs.

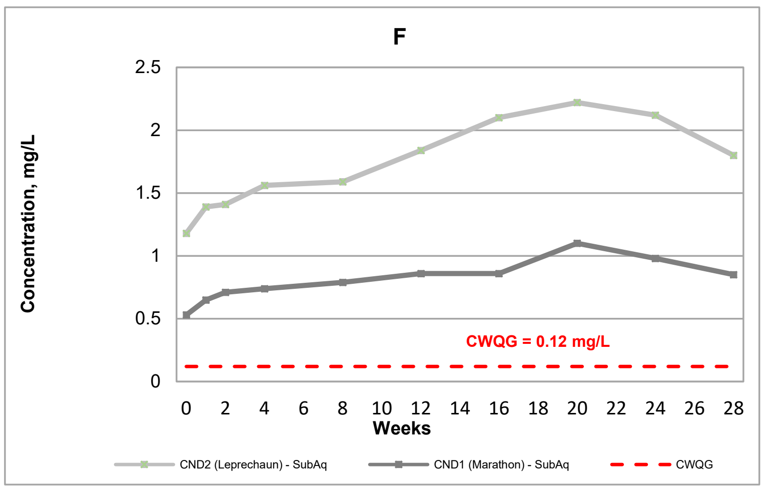


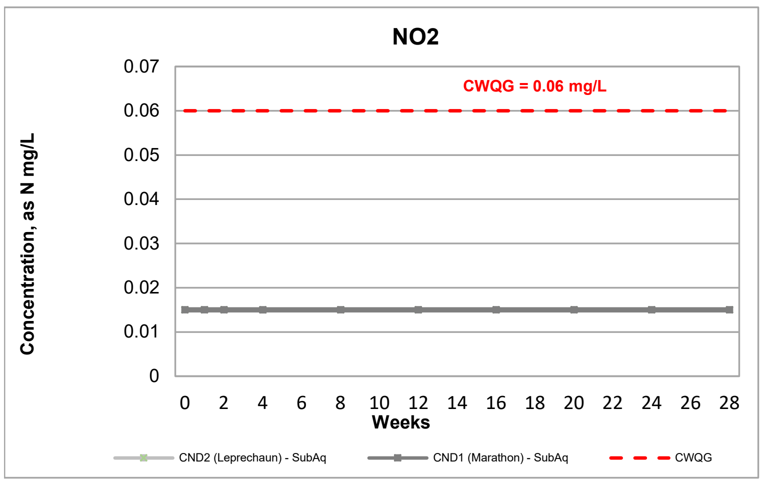


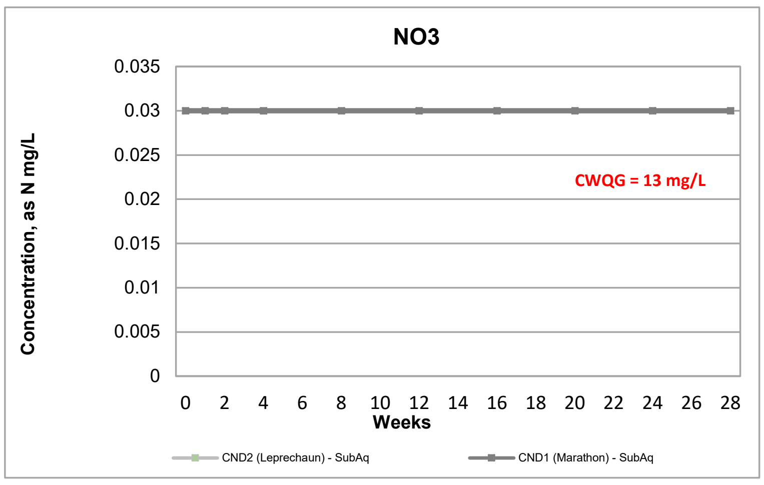


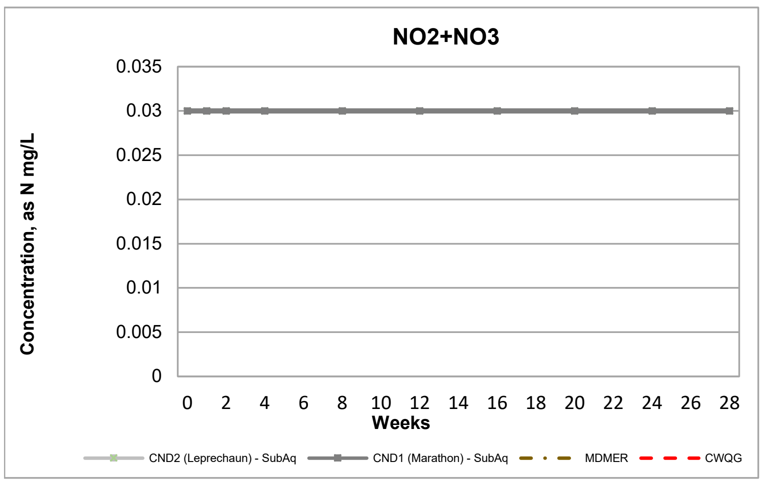


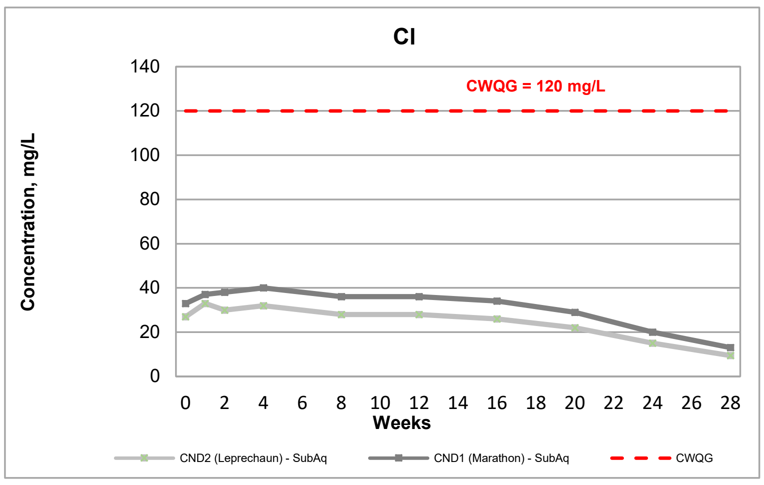


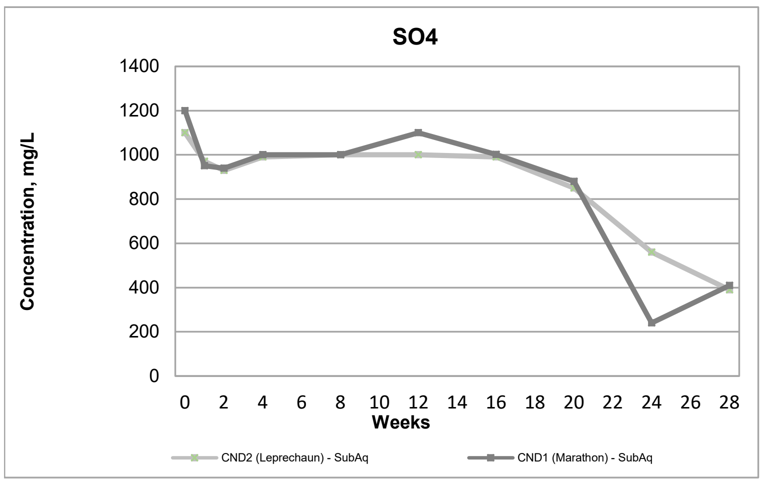


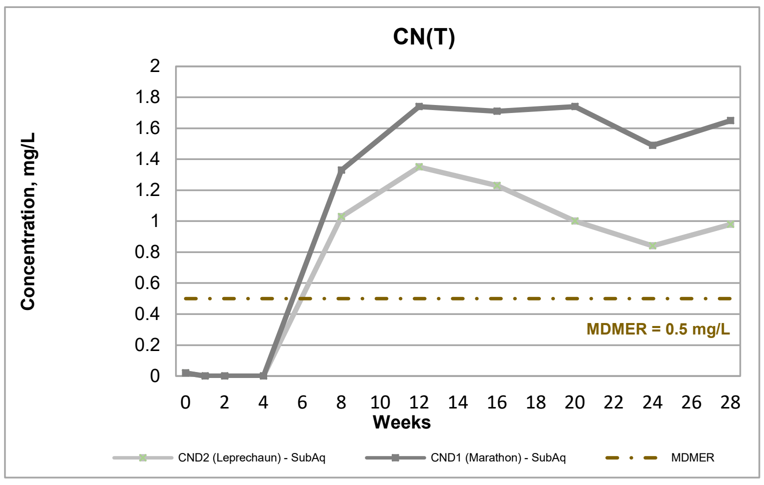






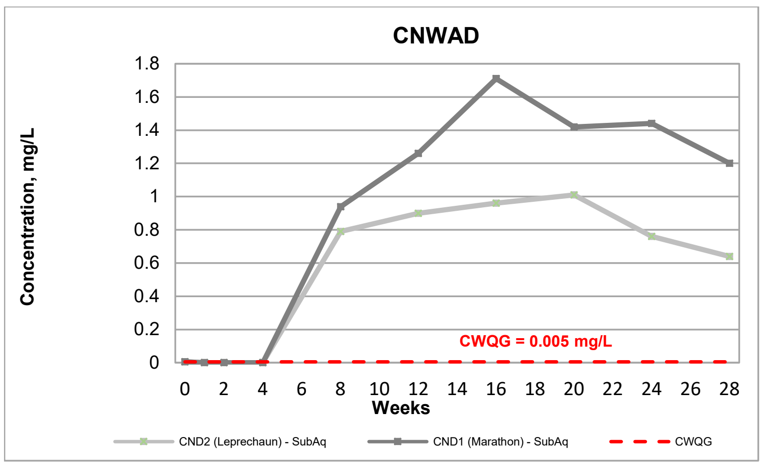


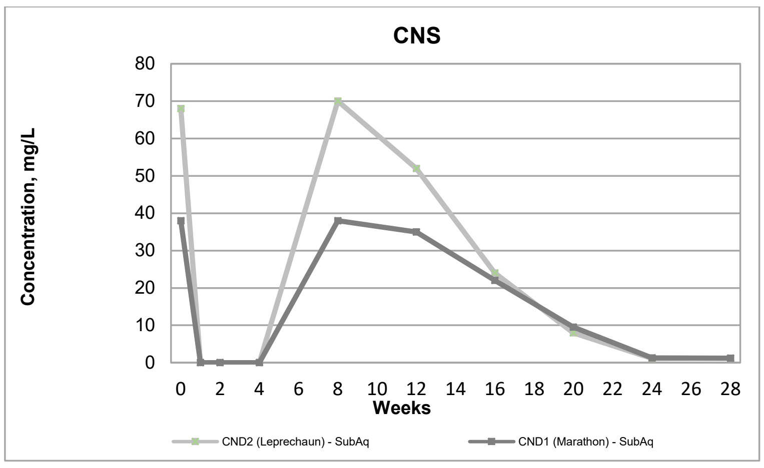


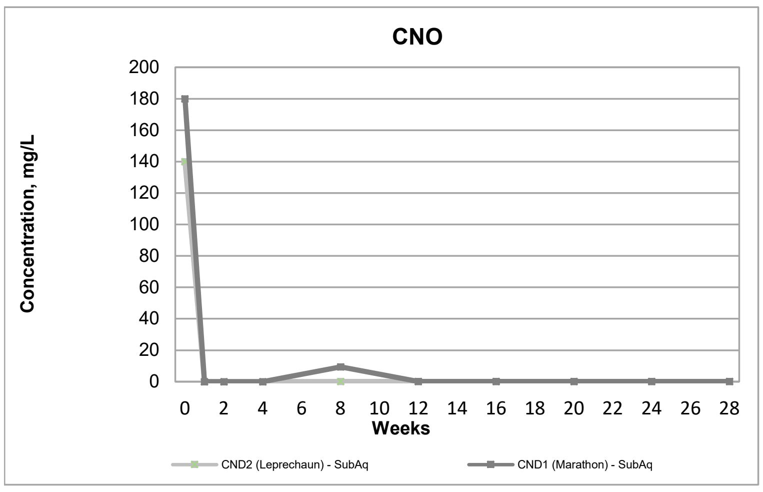


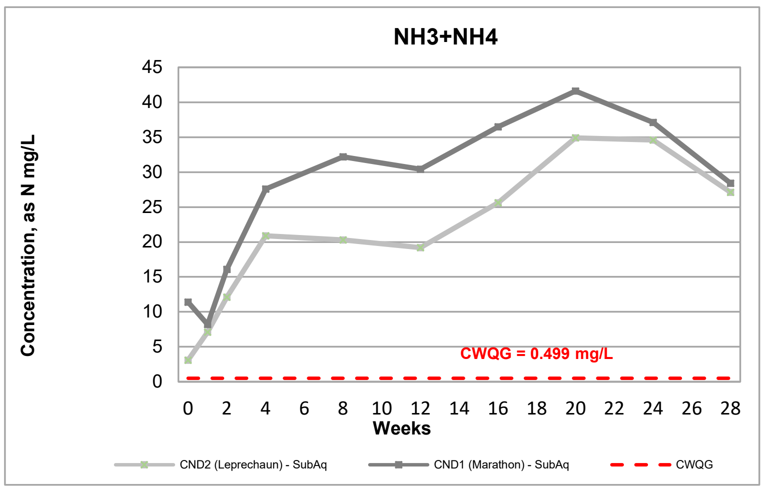
Note: Values below the respective detection limits (DLs) are shown as half DLs.

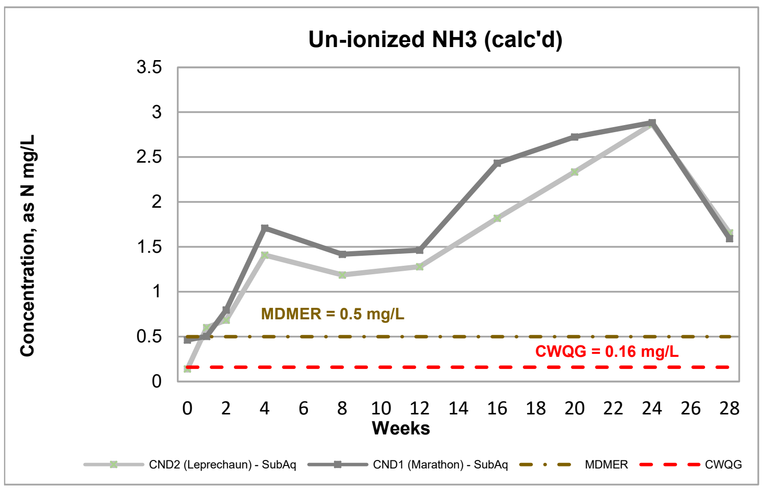
Marathon and Leprechaun tailings sub-aqueous columns

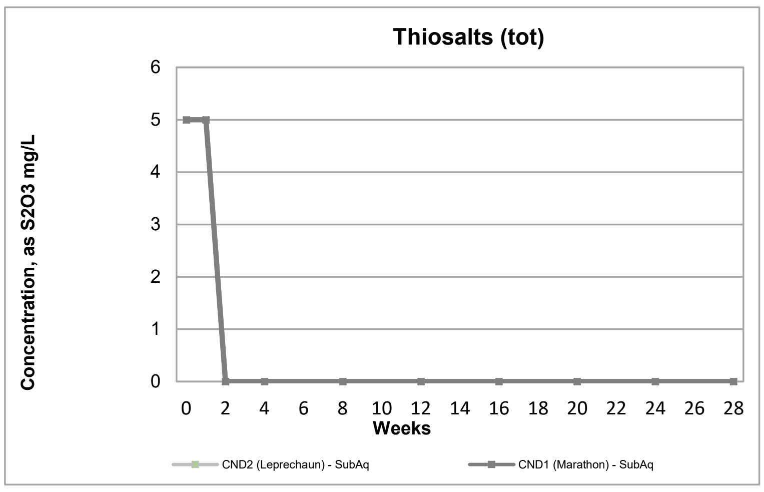


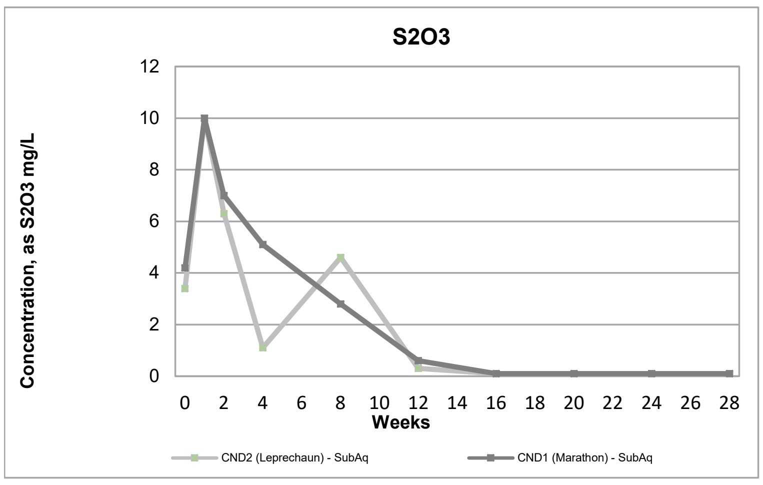


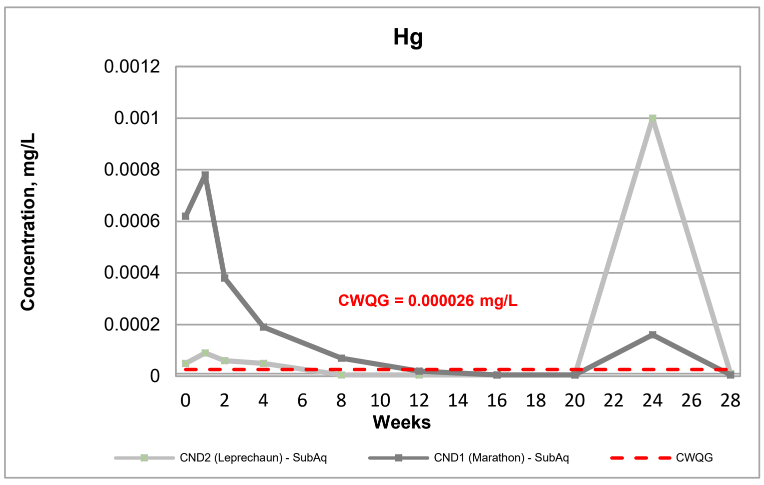


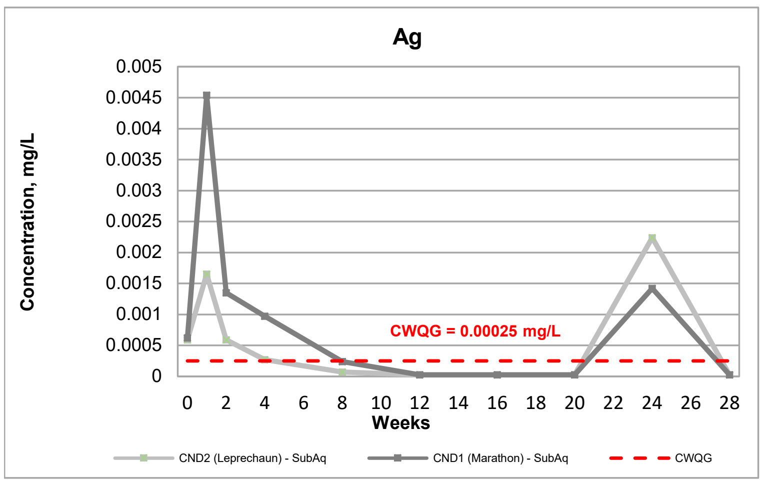


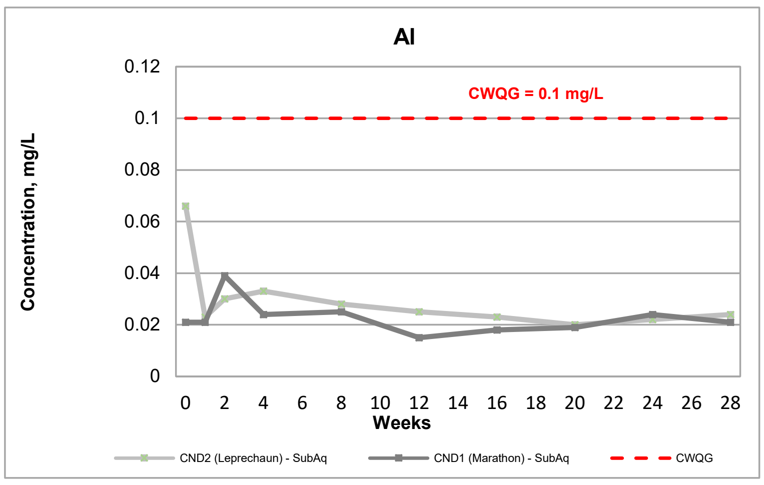


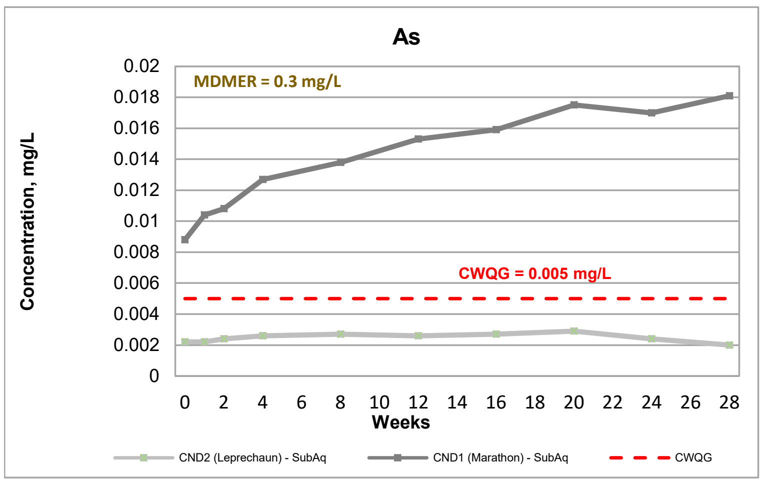


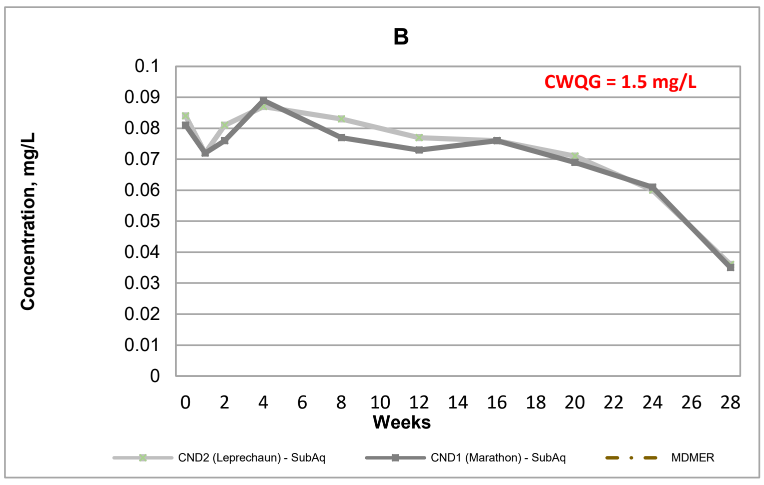






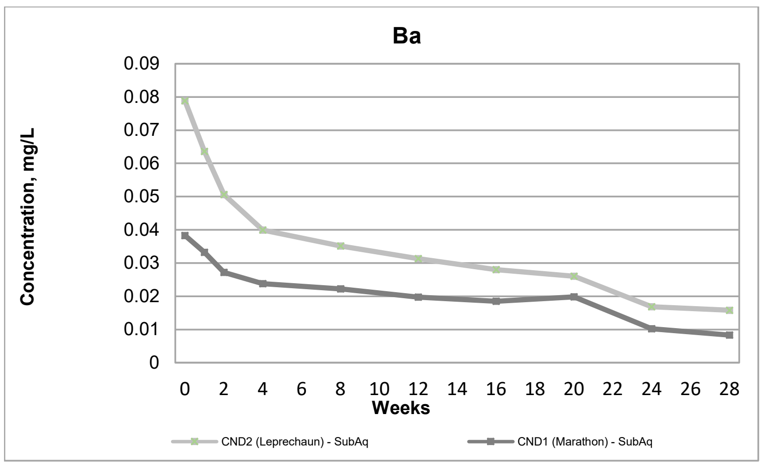


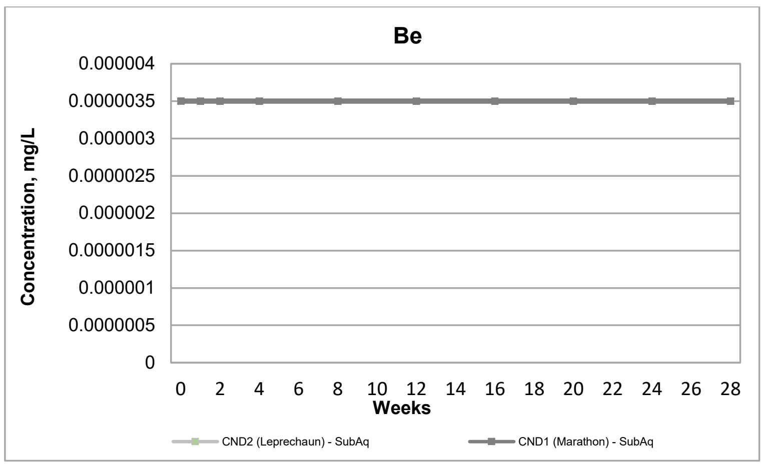


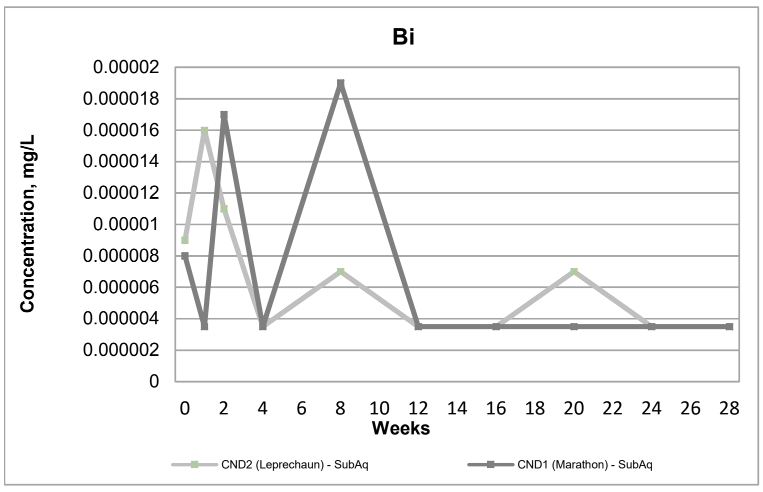


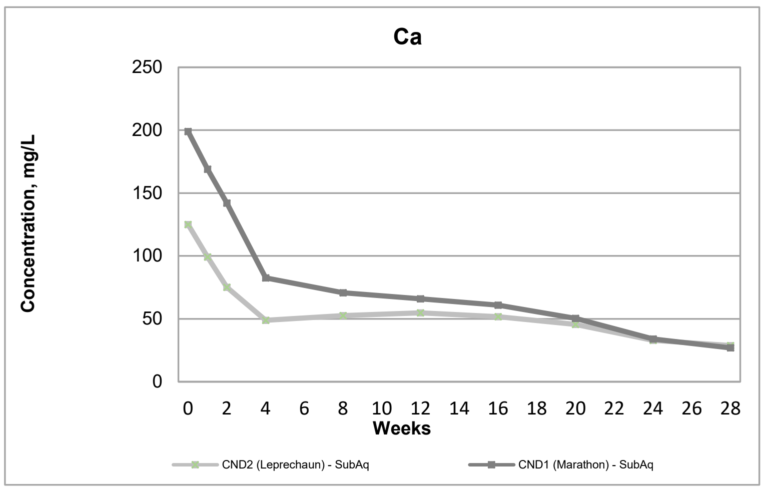
Note: Values below the respective detection limits (DLs) are shown as half DLs. CNWAD - weak acid dissociable cyanide.

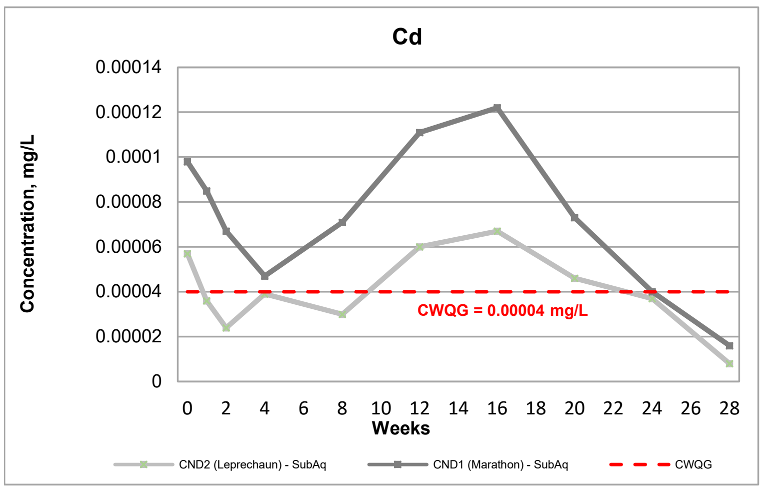
Marathon and Leprechaun tailings sub-aqueous columns

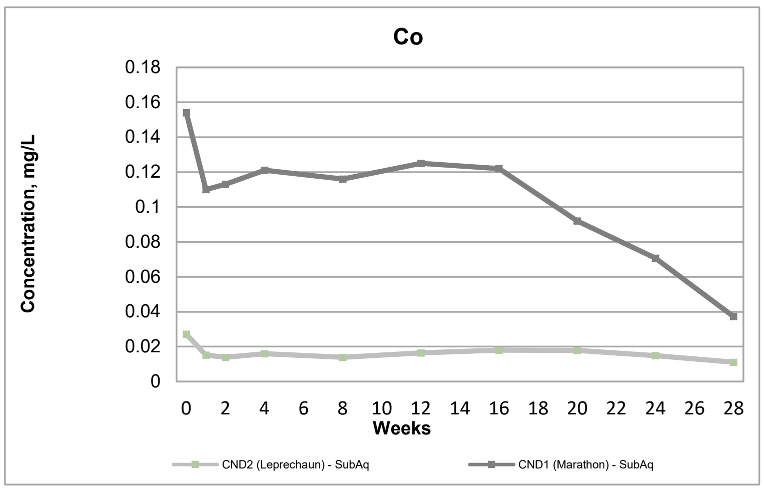


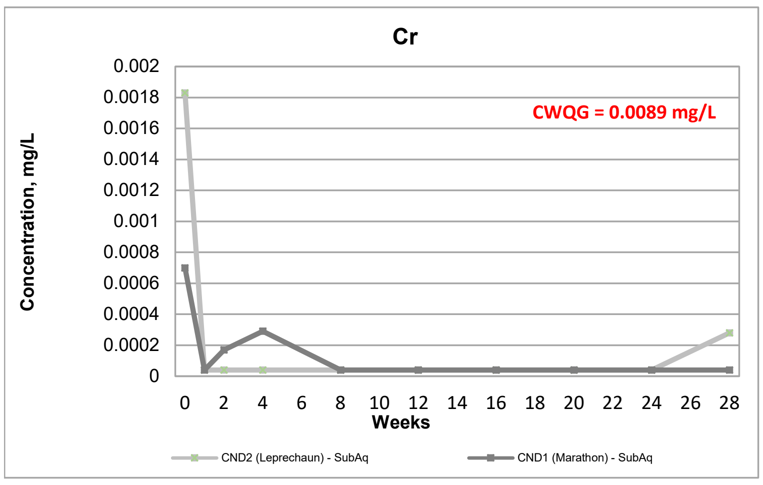


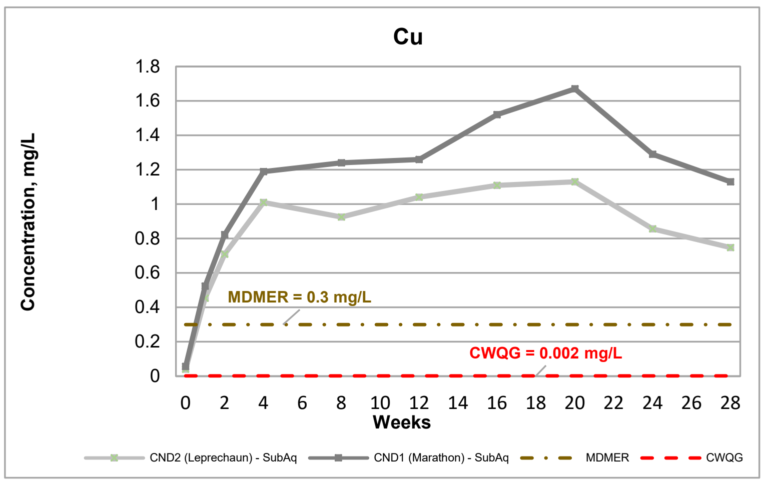


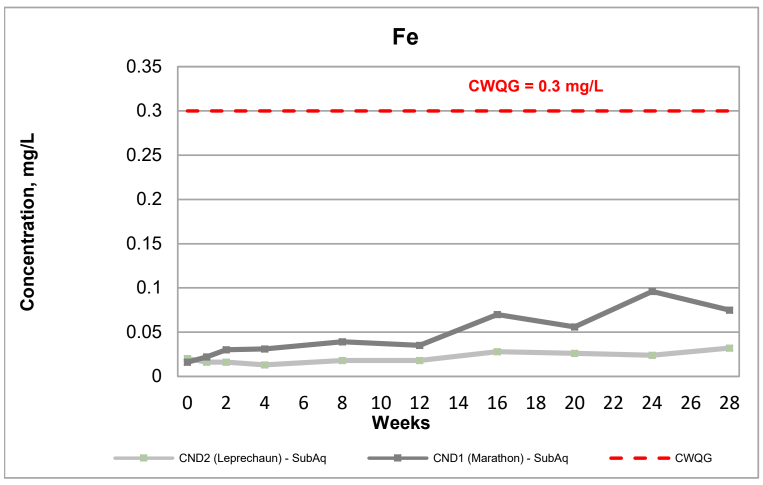


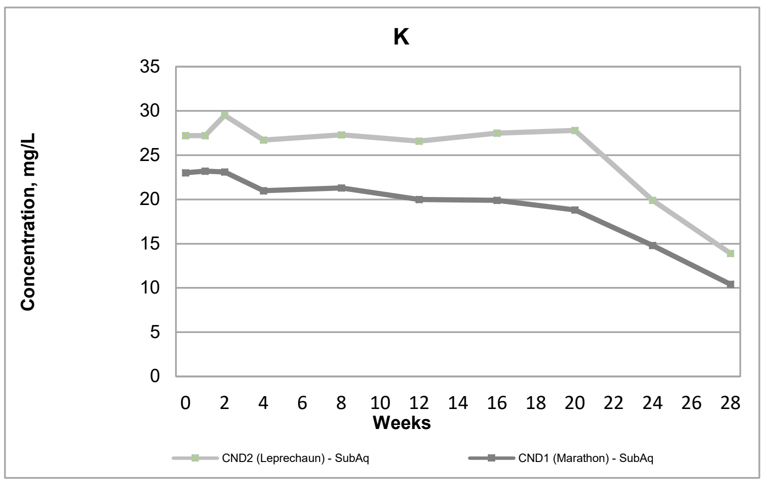


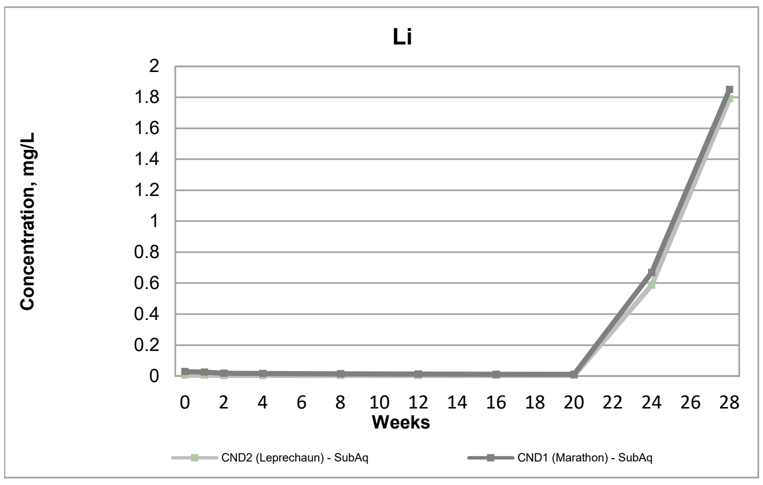


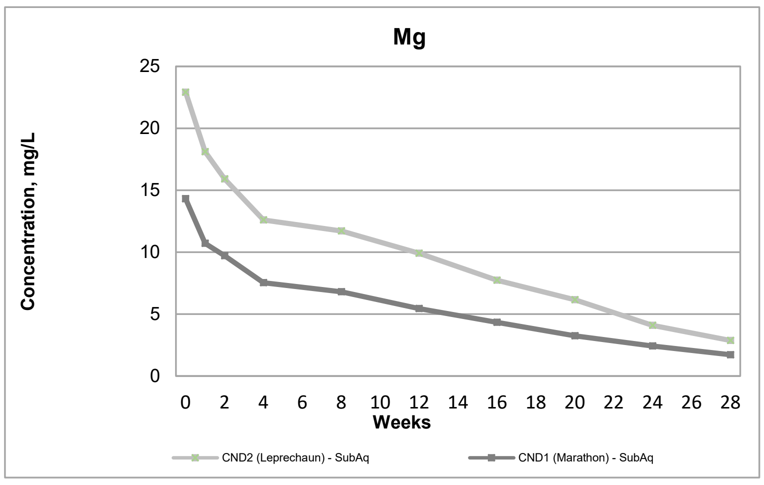






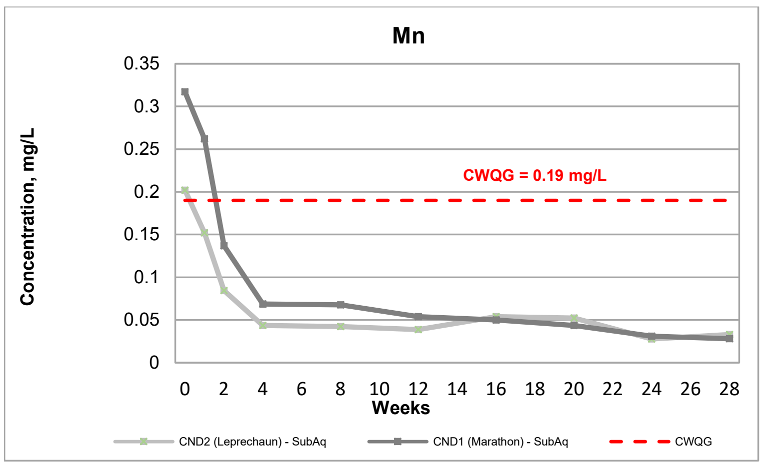


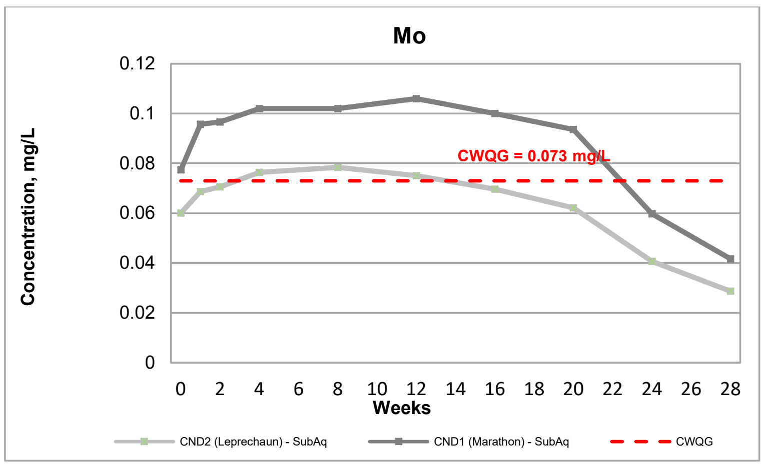


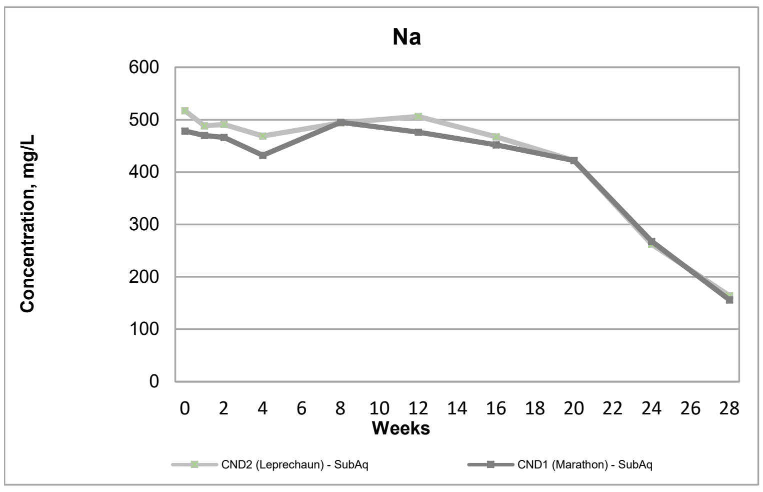


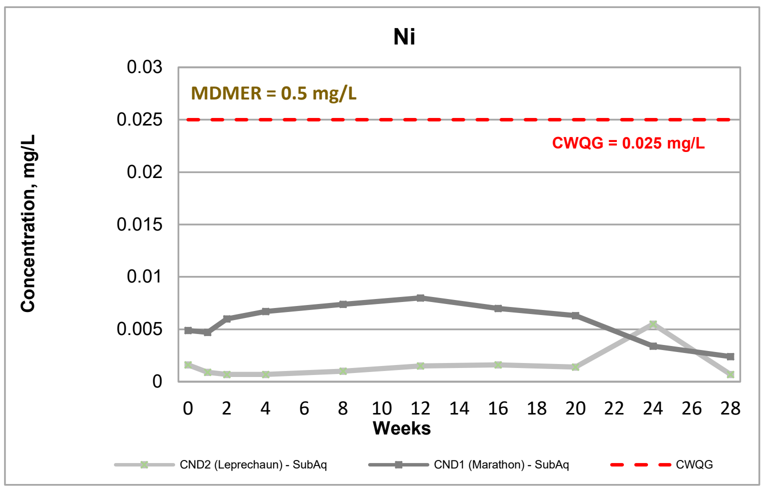
Note: Values below the respective detection limits (DLs) are shown as half DLs.

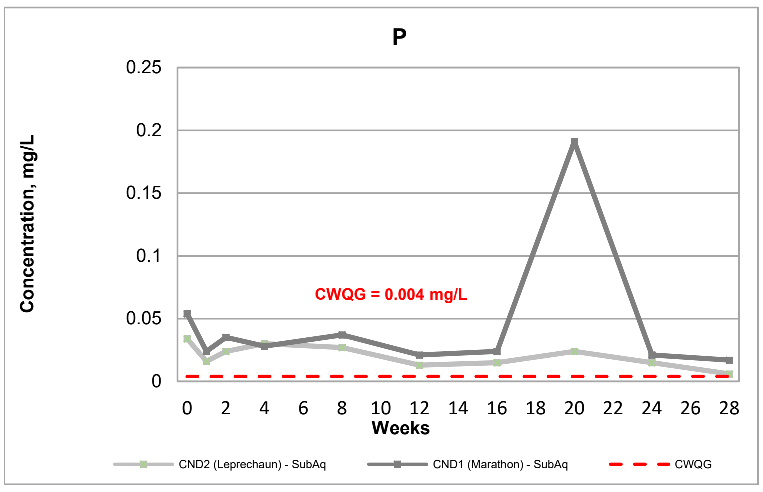
Marathon and Leprechaun tailings sub-aqueous columns

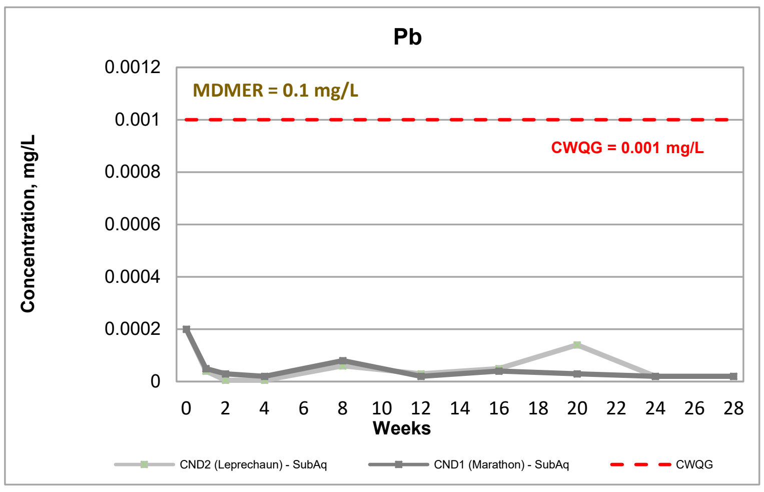


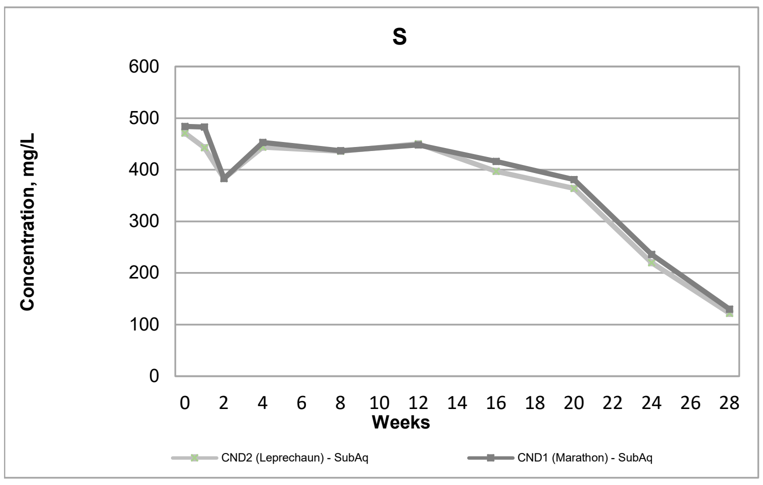


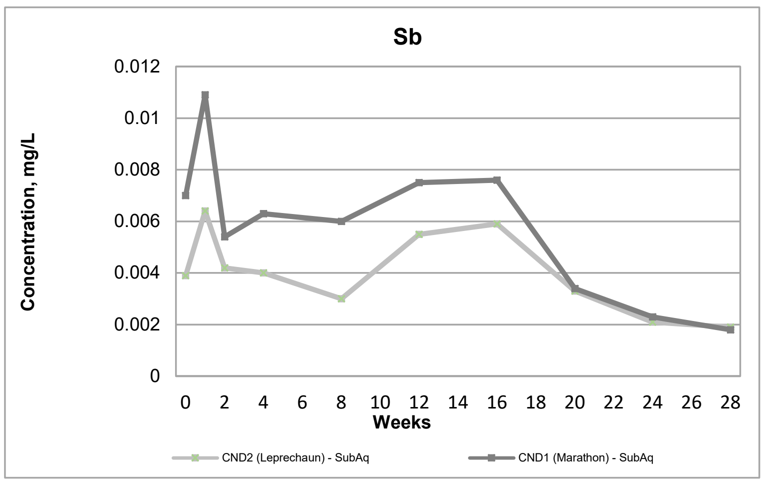


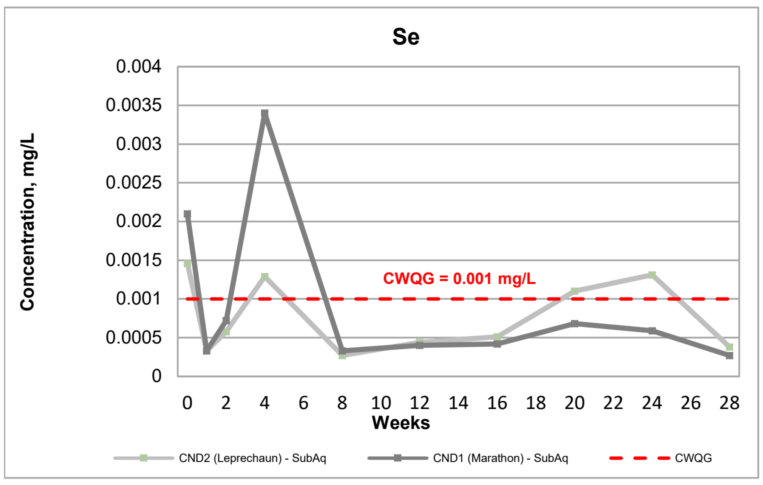


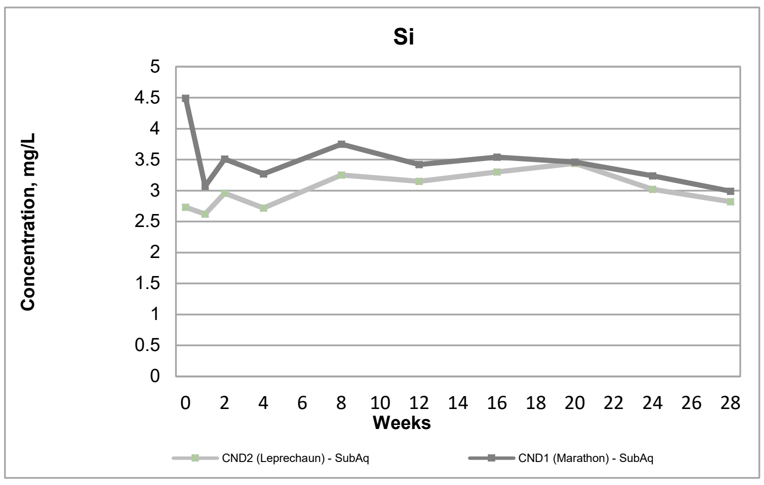


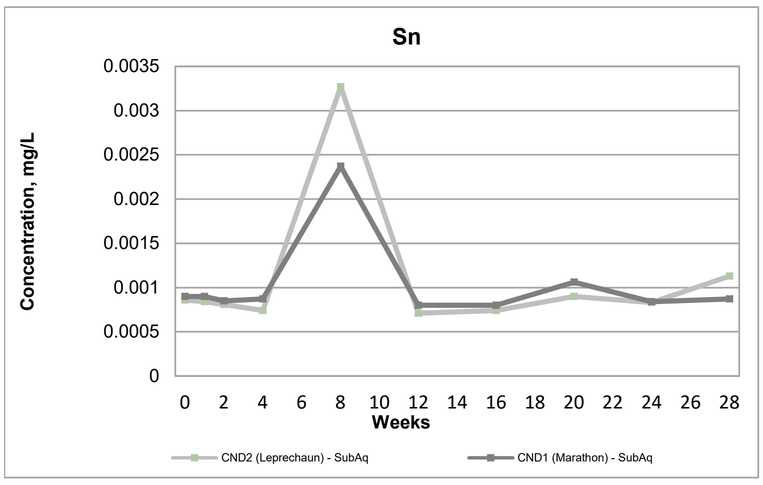


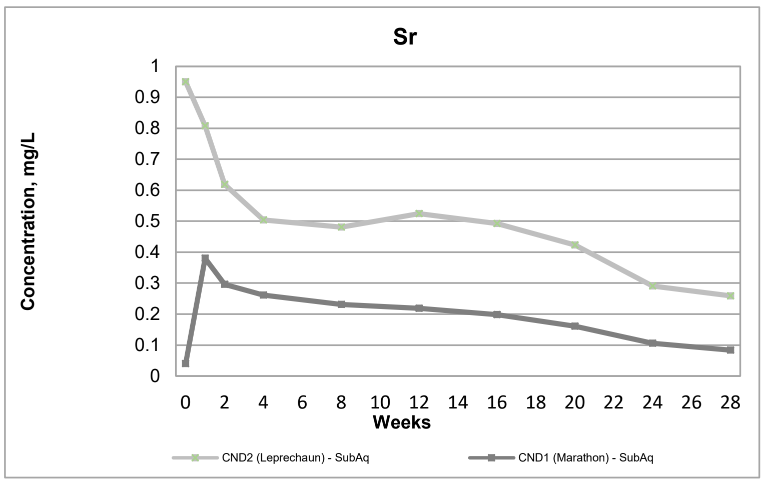






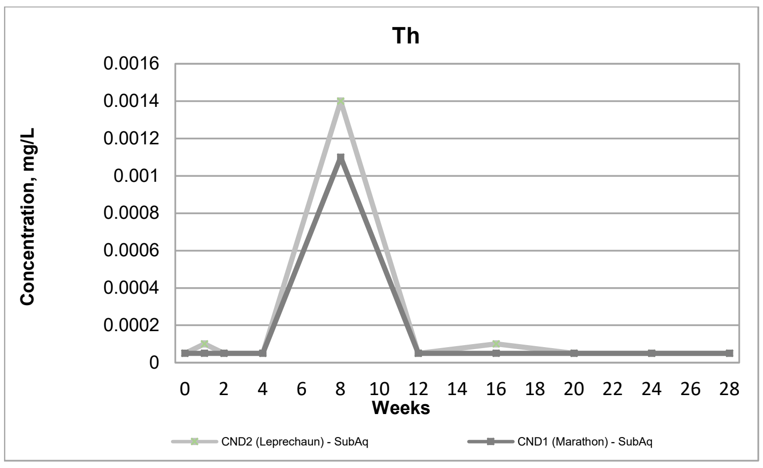


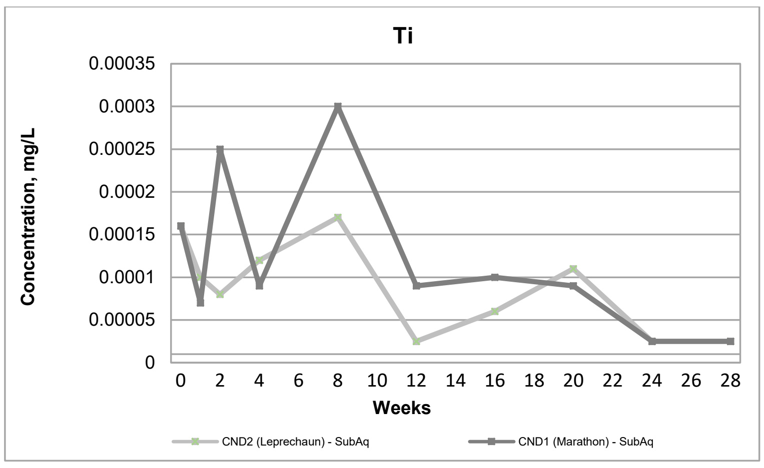


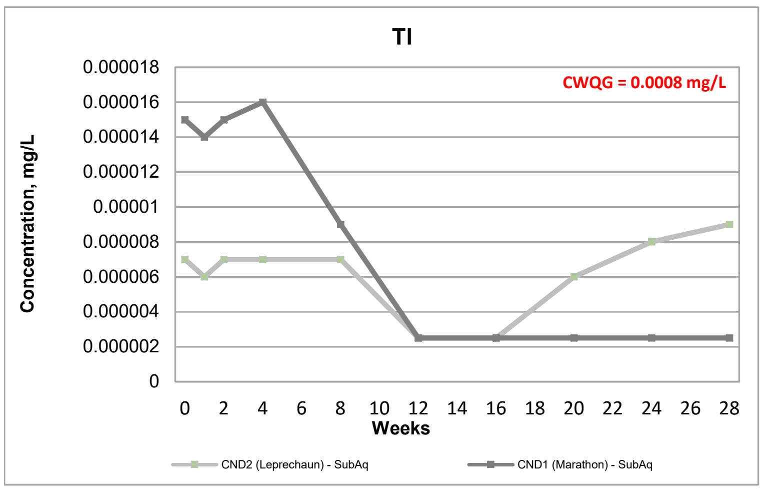


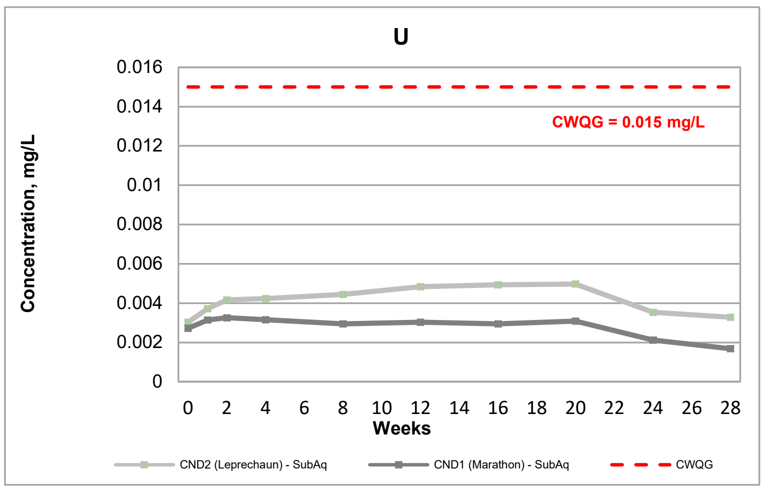
Note: Values below the respective detection limits (DLs) are shown as half DLs.

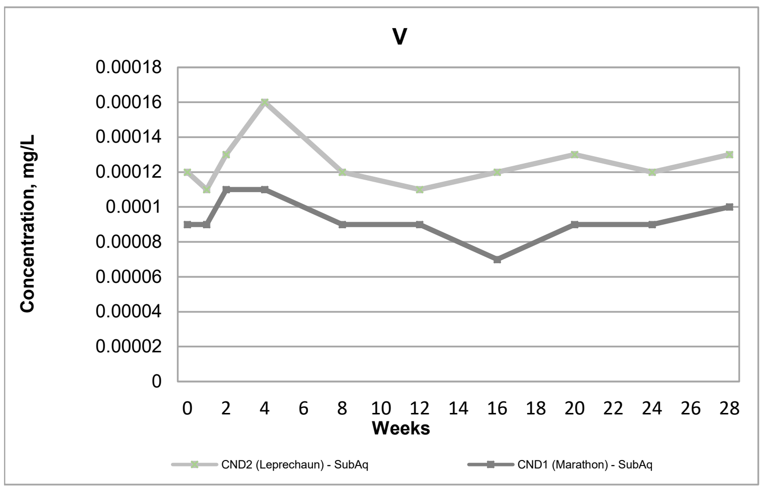
Marathon and Leprechaun tailings sub-aqueous columns

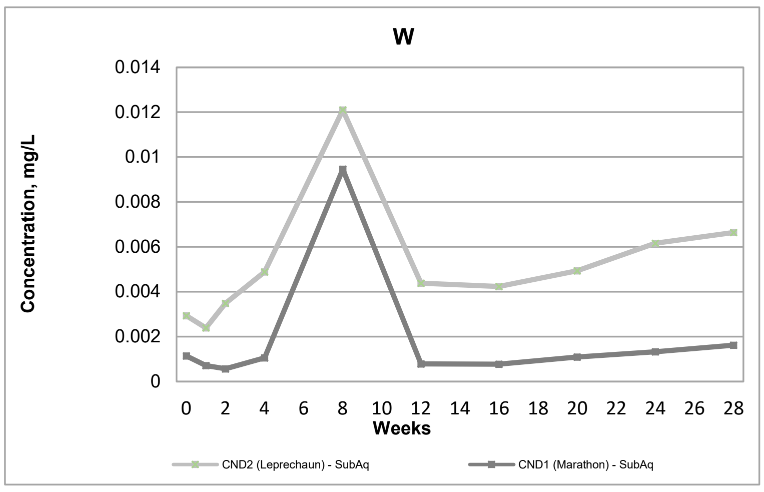


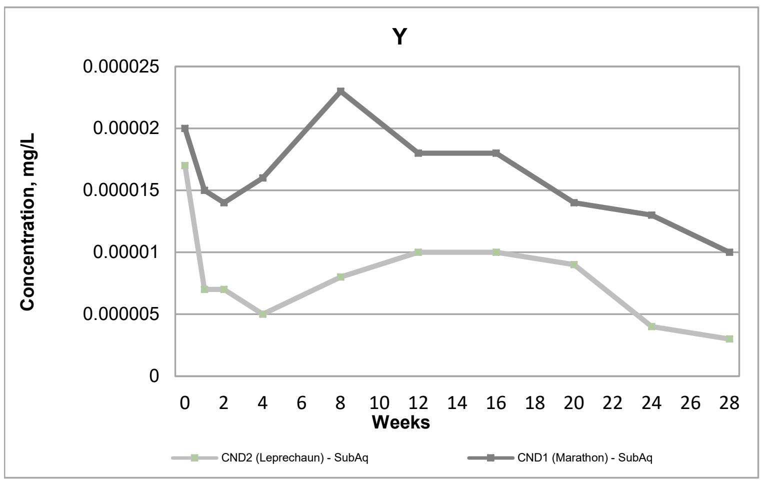


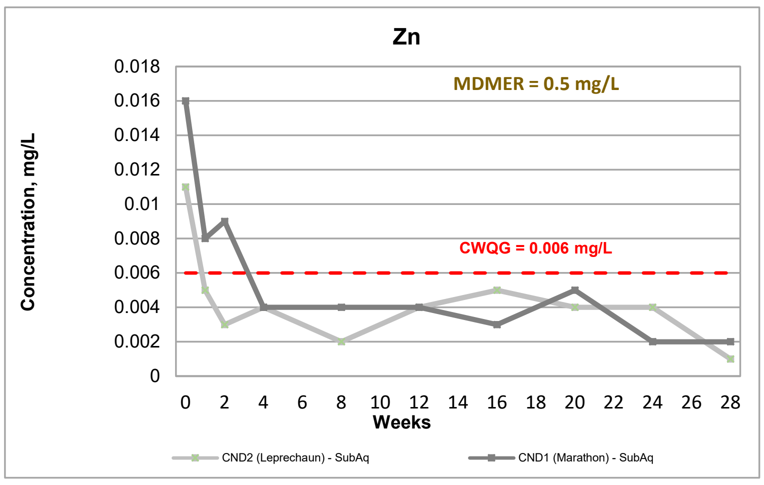












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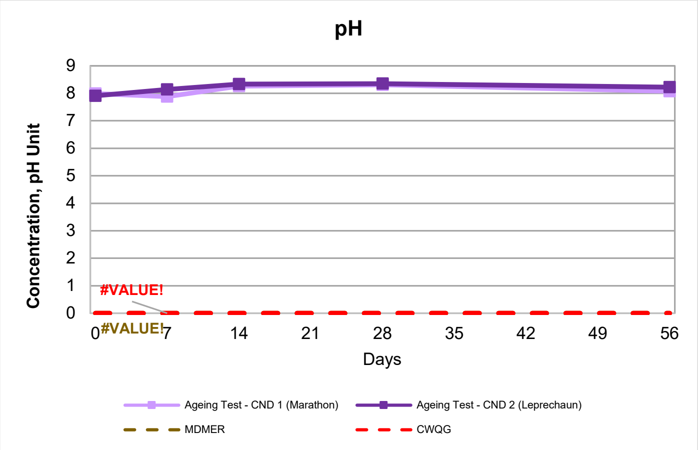
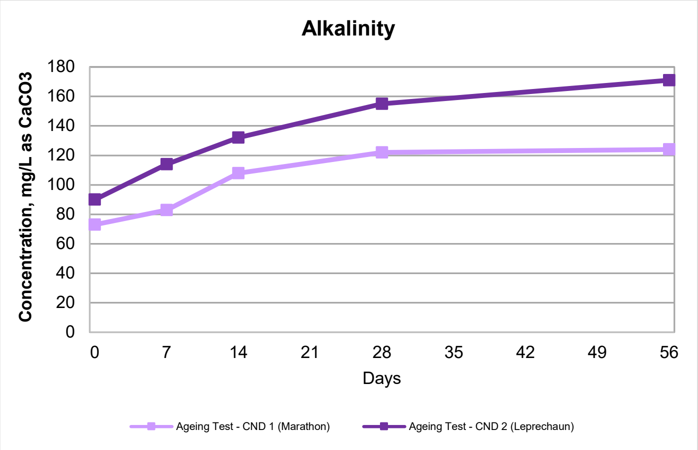
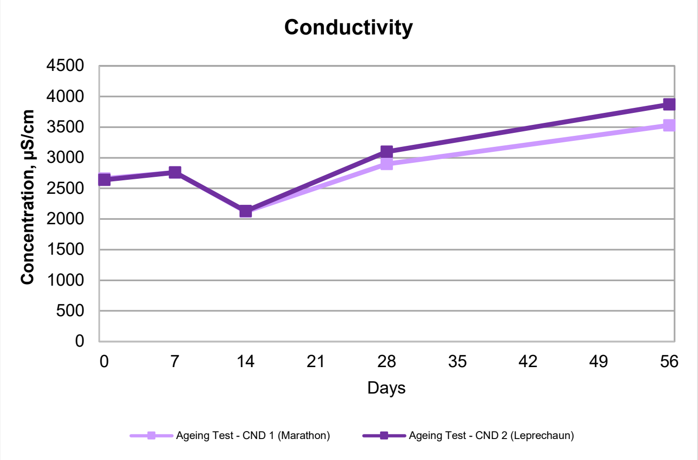
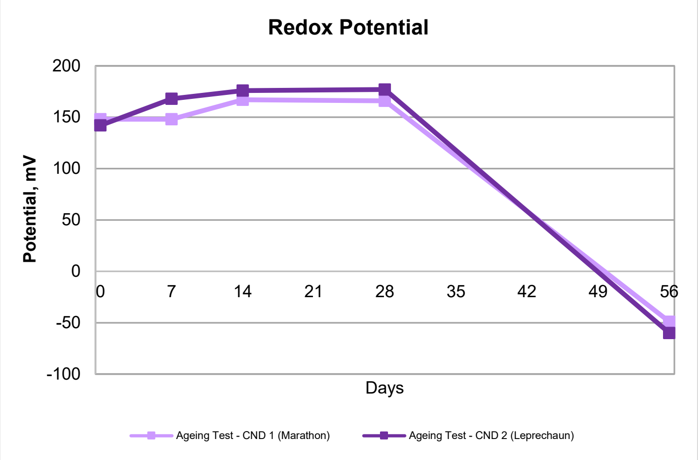
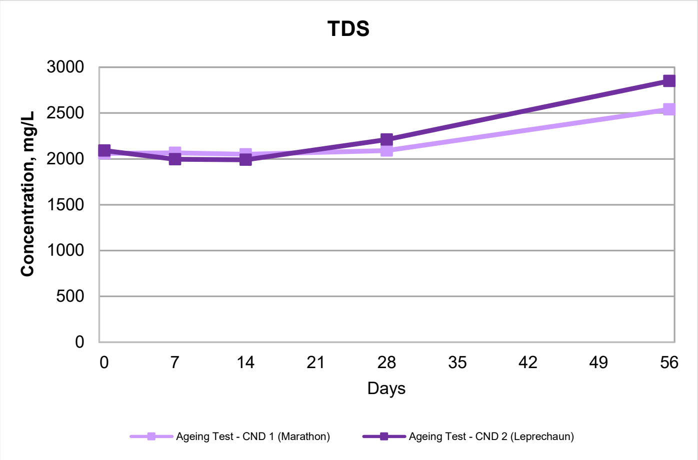
Marathon and Leprechaun process water ageing tests

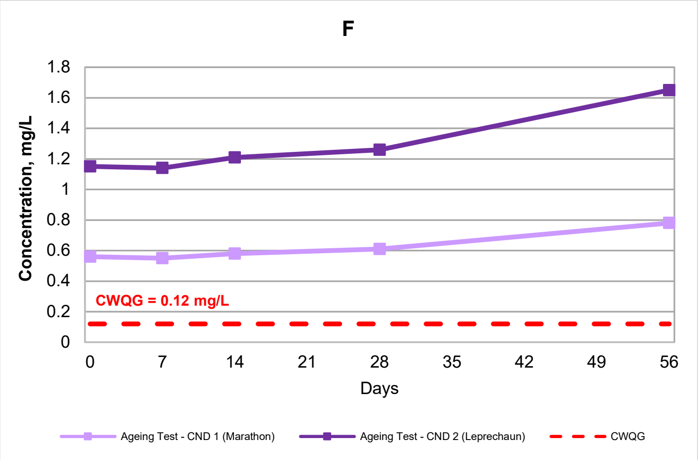


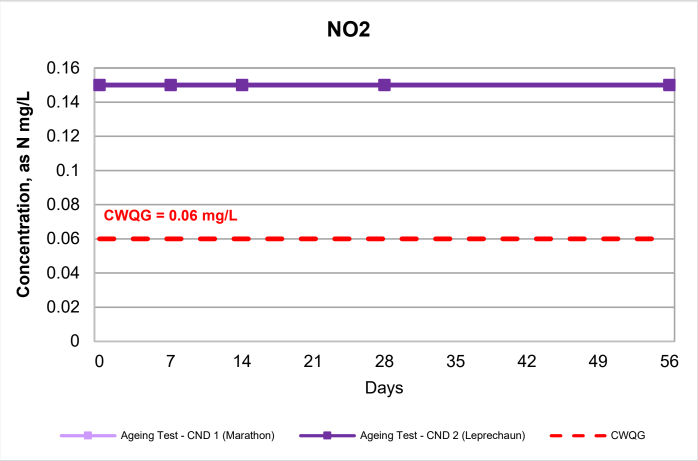


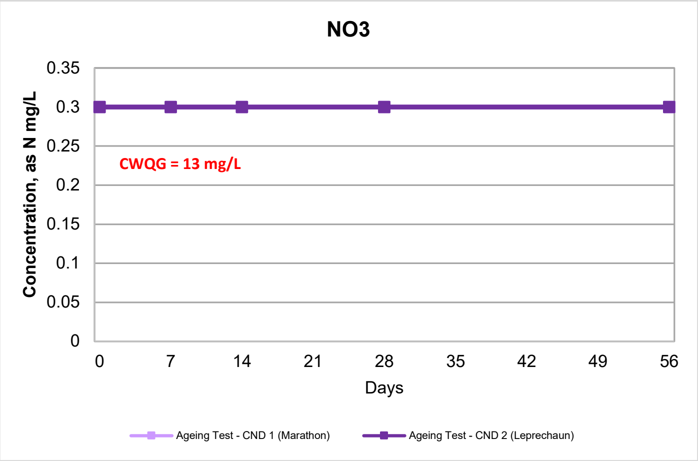


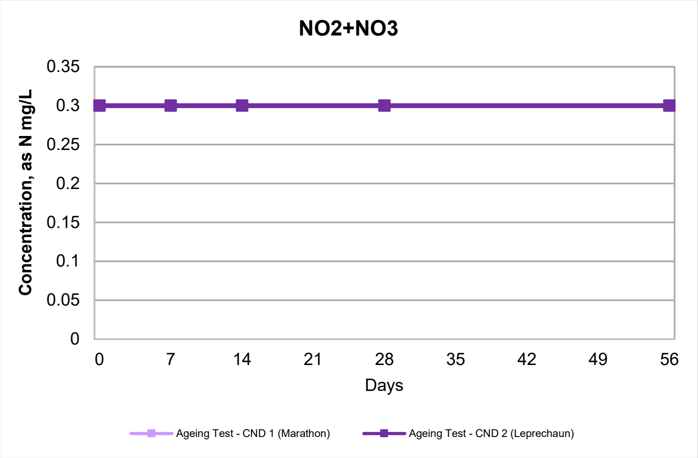


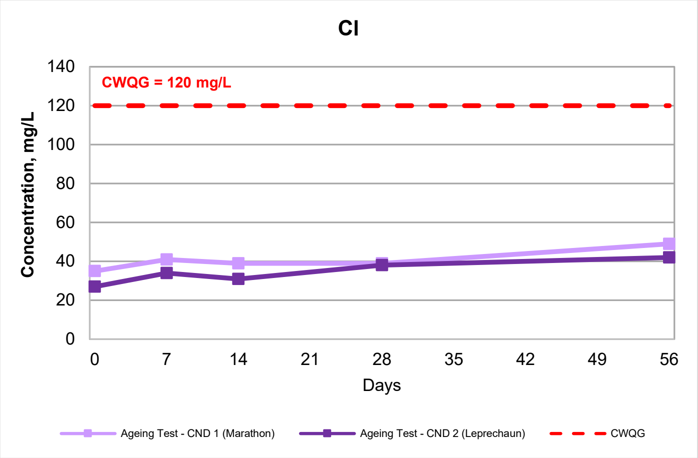


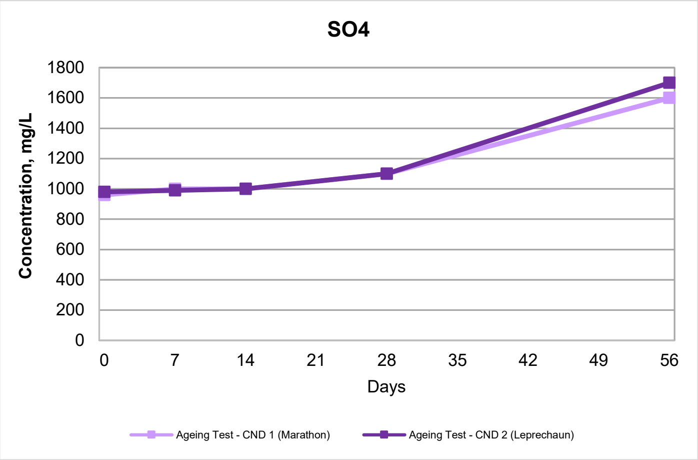


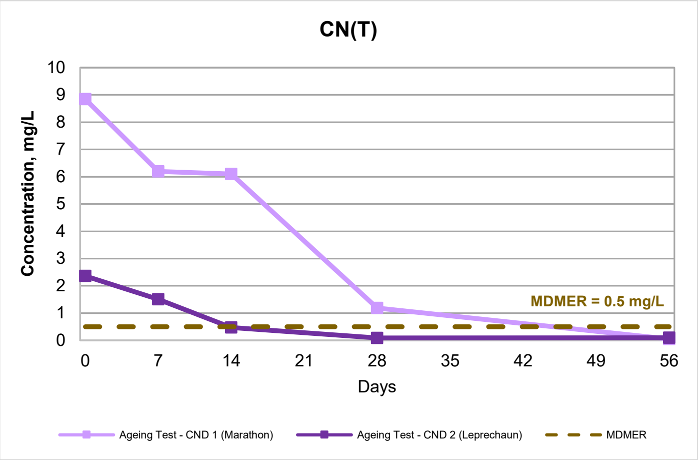






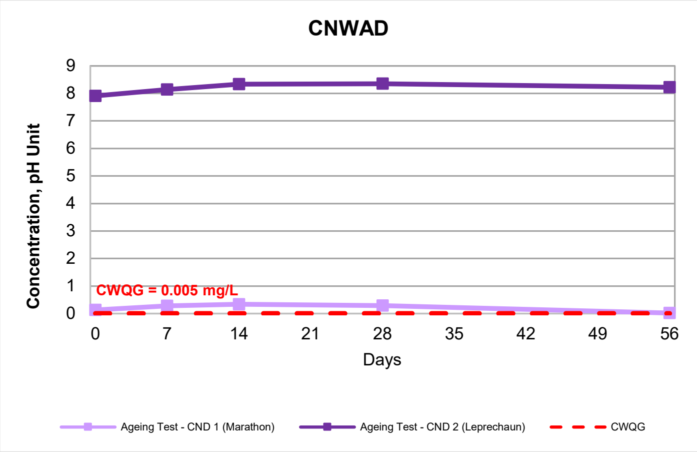


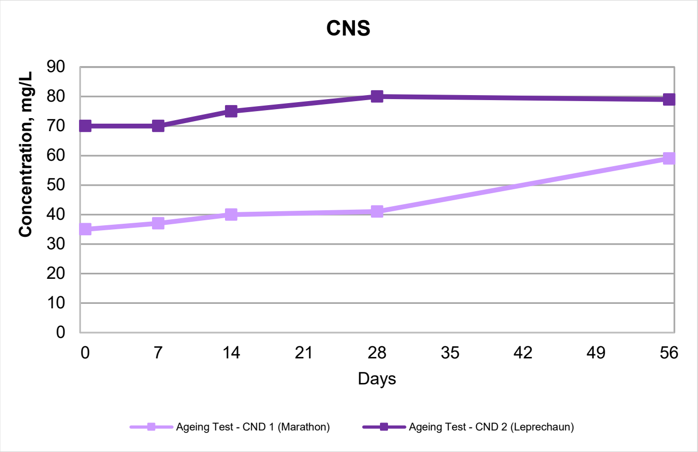


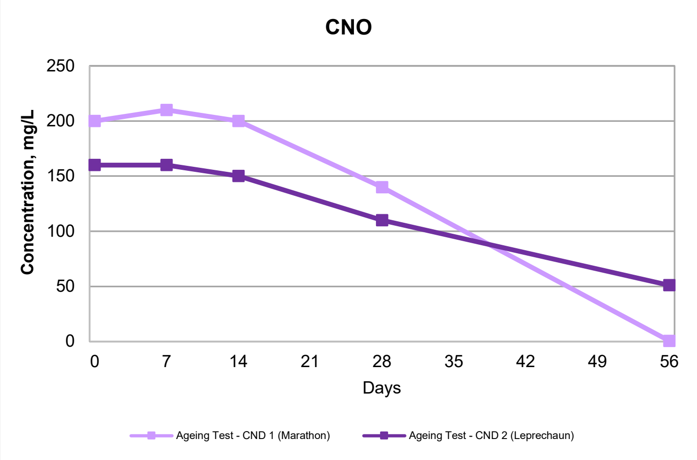


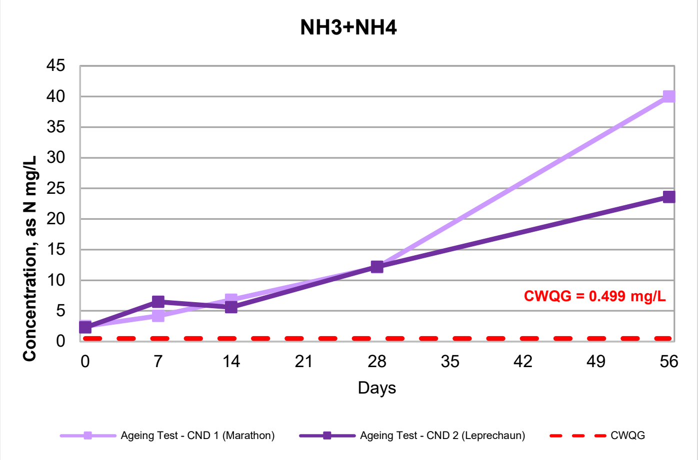
Note: Values below the respective detection limits (DLs) are shown as half DLs.

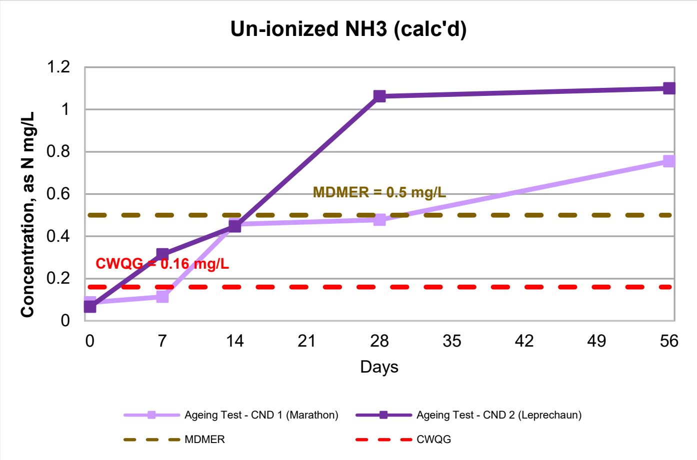
Marathon and Leprechaun process water ageing tests

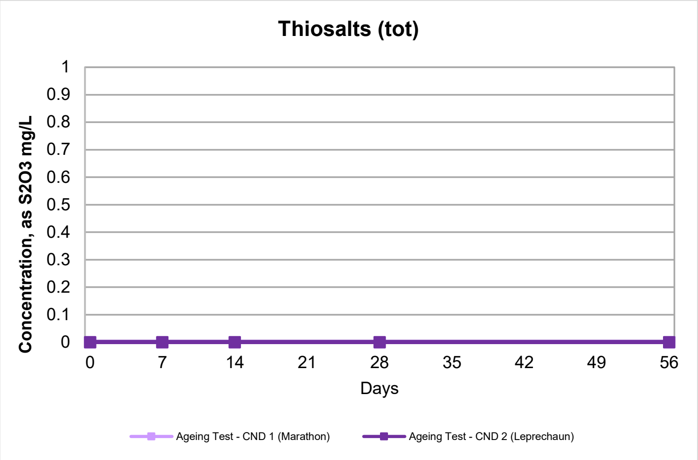

CNWAD

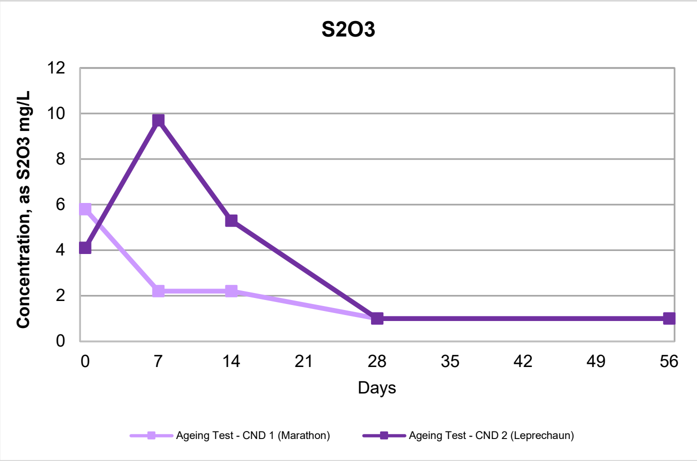

CNS

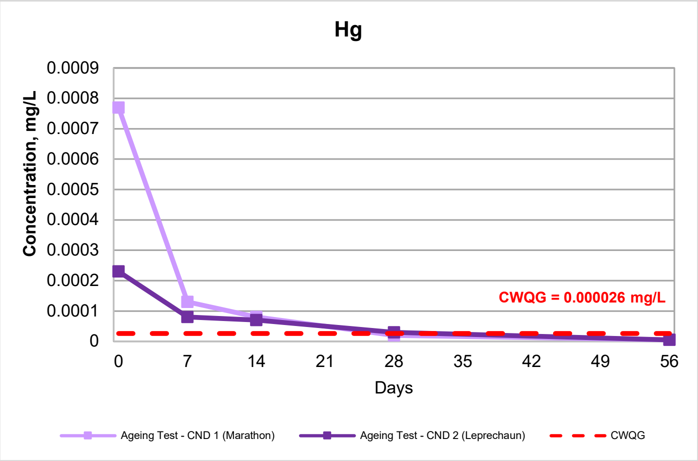

CNO

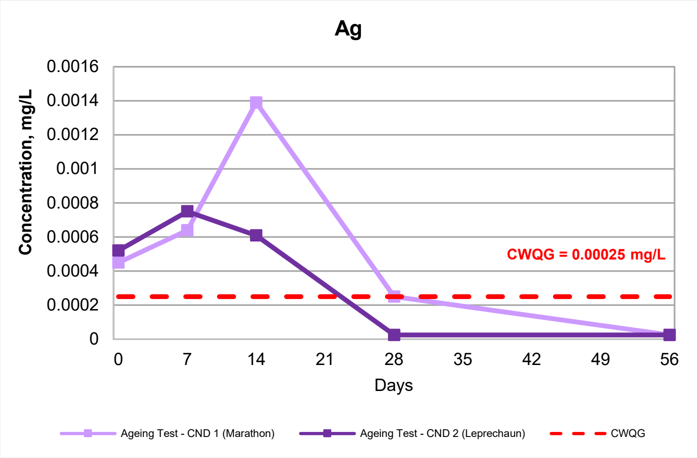

NH3+NH4

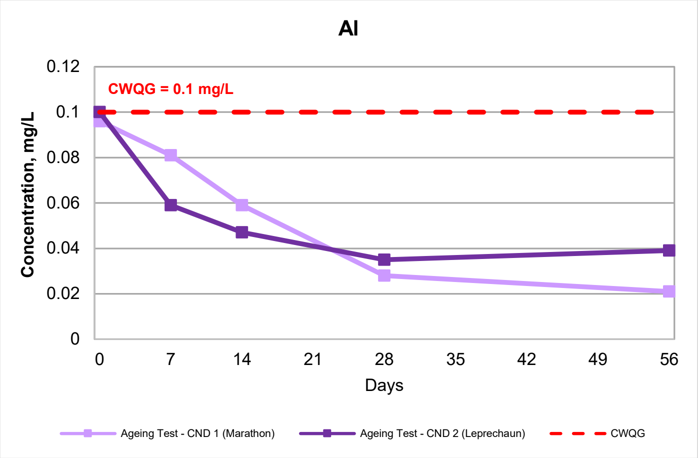

Un-ionized NH3 (calc'd)

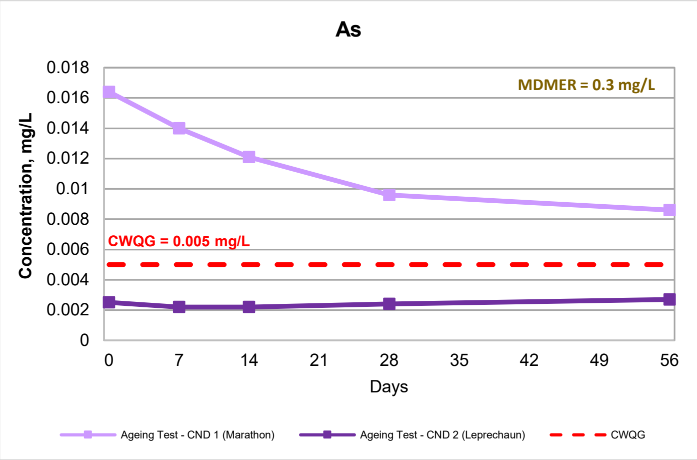

Thiosalts (tot)

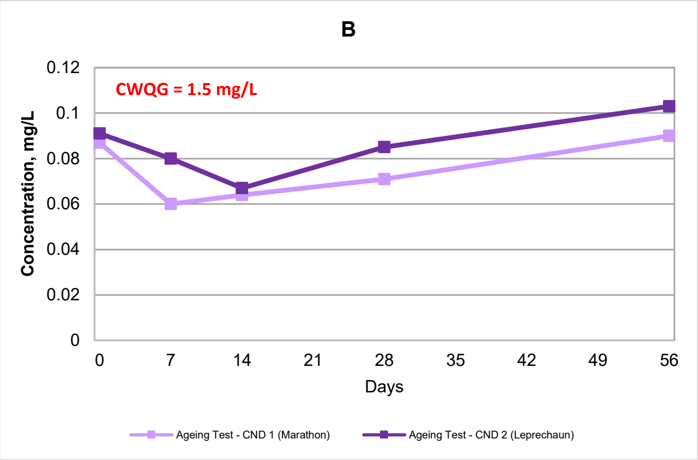

S2O3


Hg


Ag

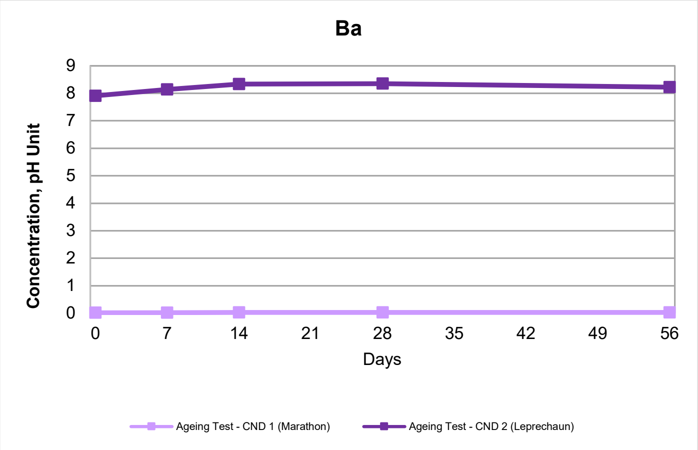

Al

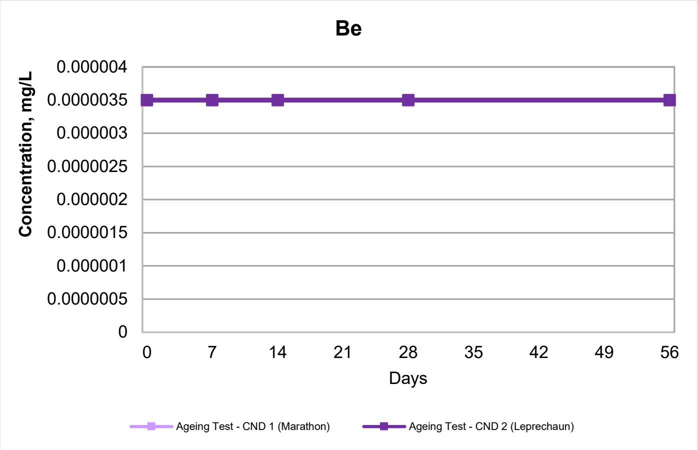

As

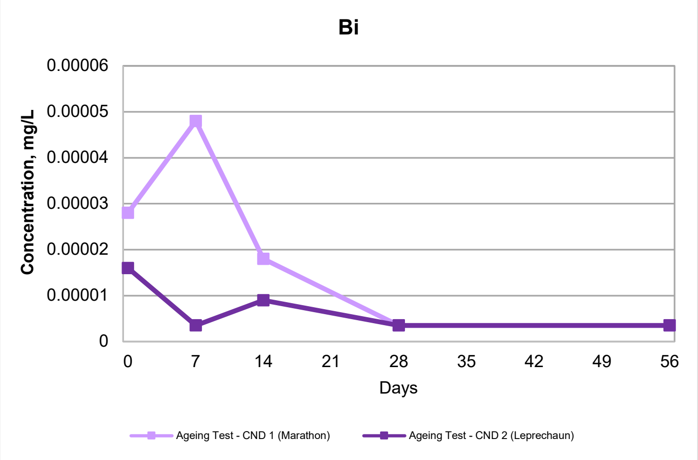

B

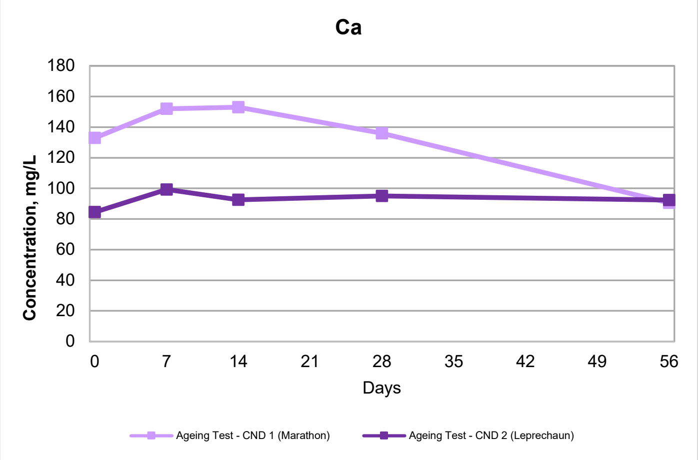
Note: Values below the respective detection limits (DLs) are shown as half DLs. CNWAD - weak acid dissociable cyanide.

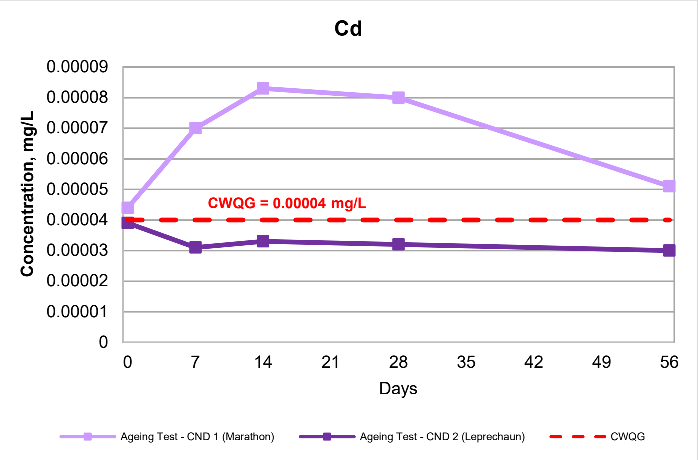
Marathon and Leprechaun process water ageing tests

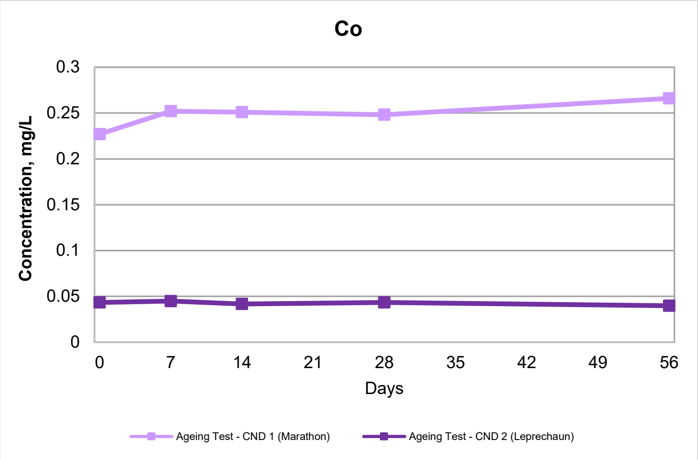

Ba

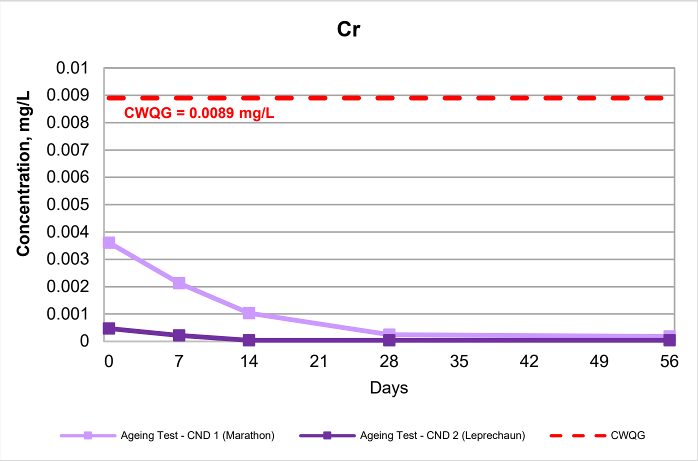

Be

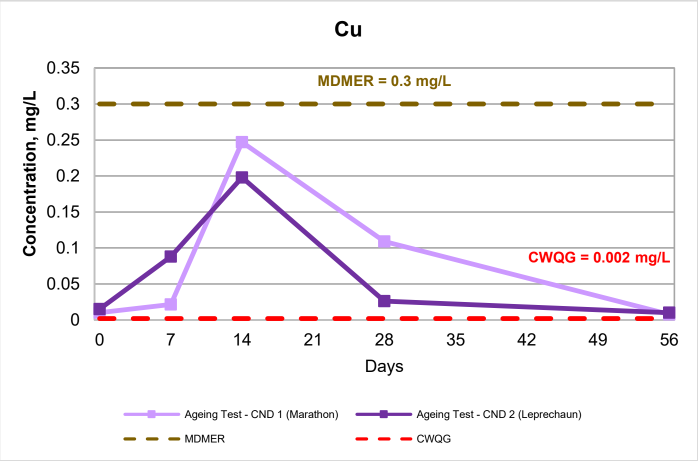

Bi

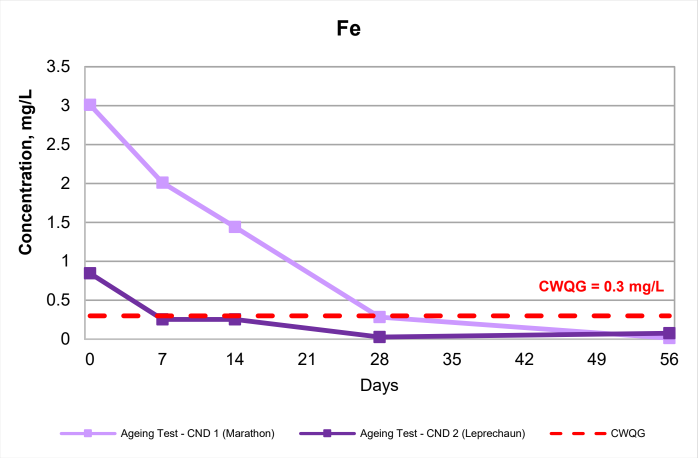

Ca

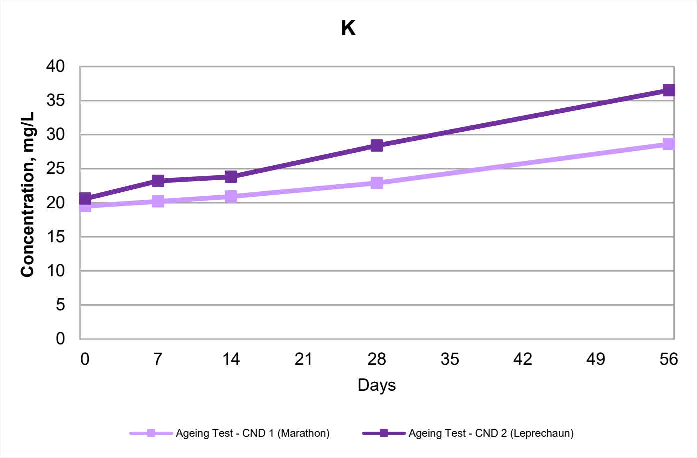

Cd

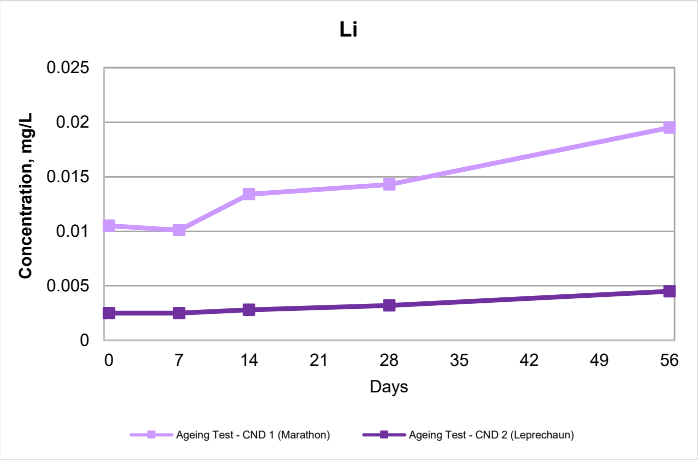

Co

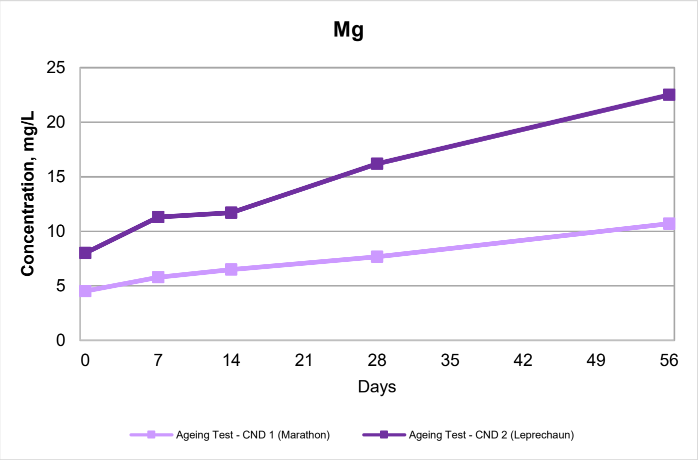

Cr


Cu


Fe

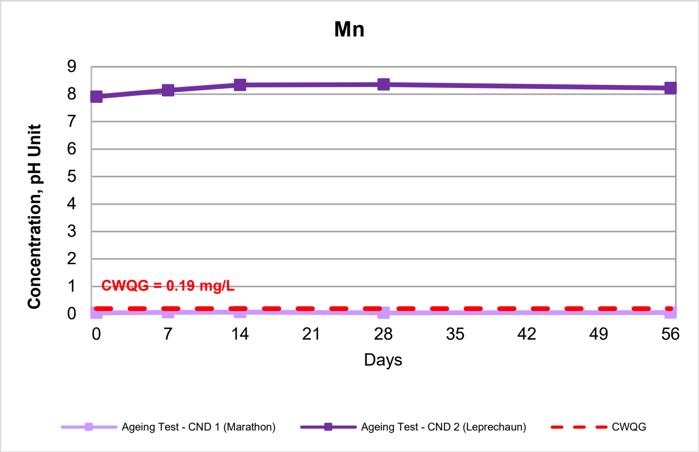

K

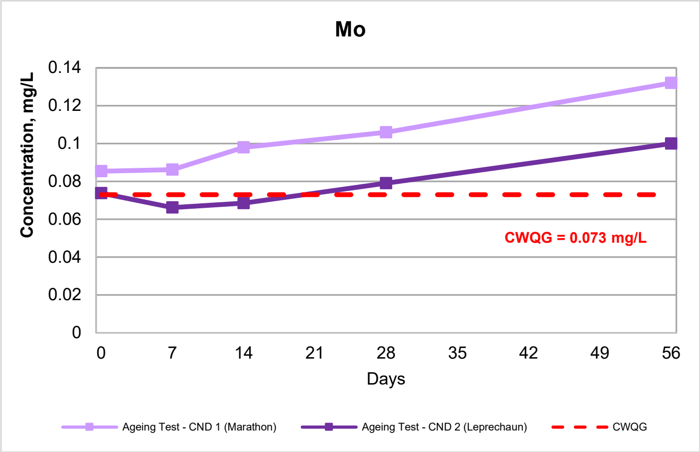

Li

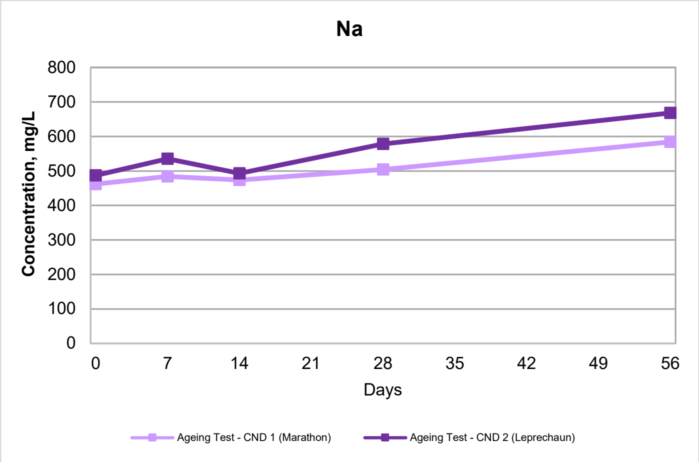

Mg

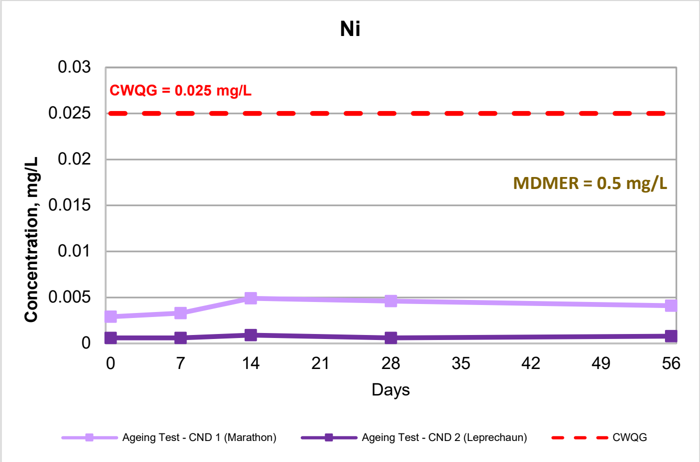
Note: Values below the respective detection limits (DLs) are shown as half DLs.

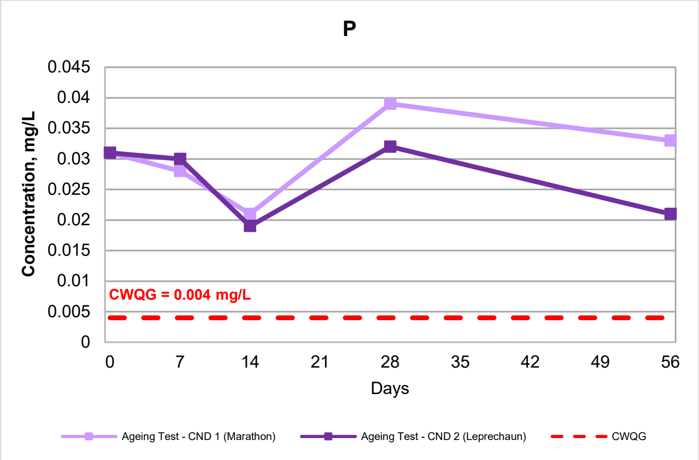
Marathon and Leprechaun process water ageing tests

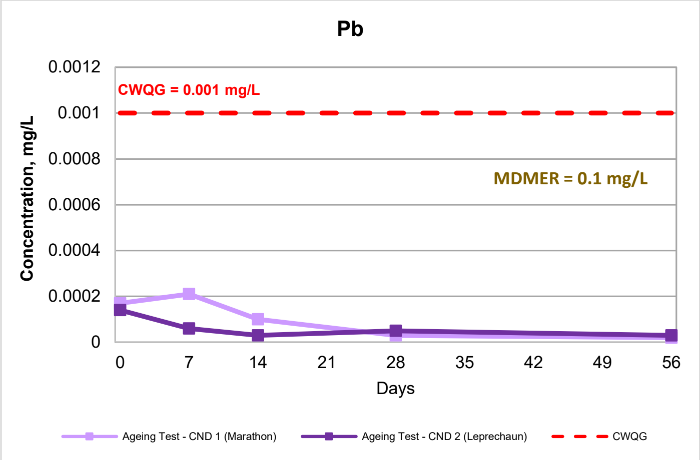


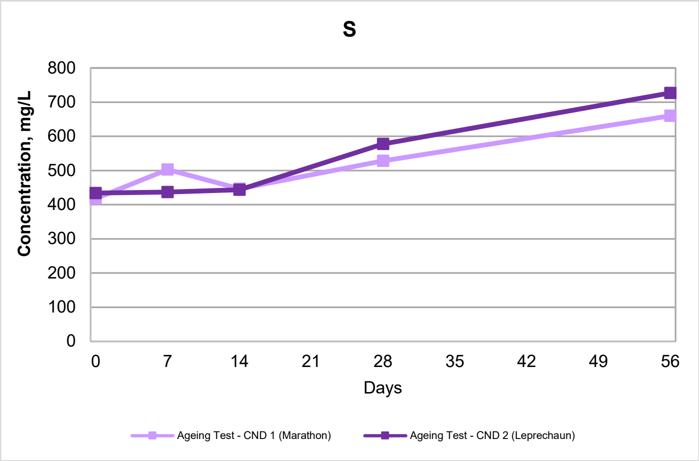


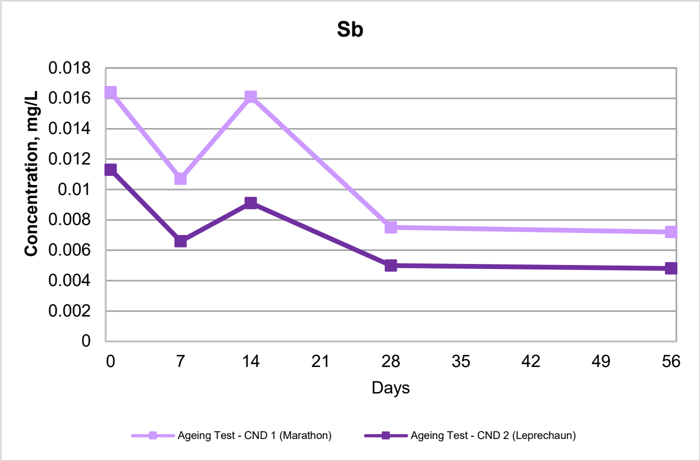


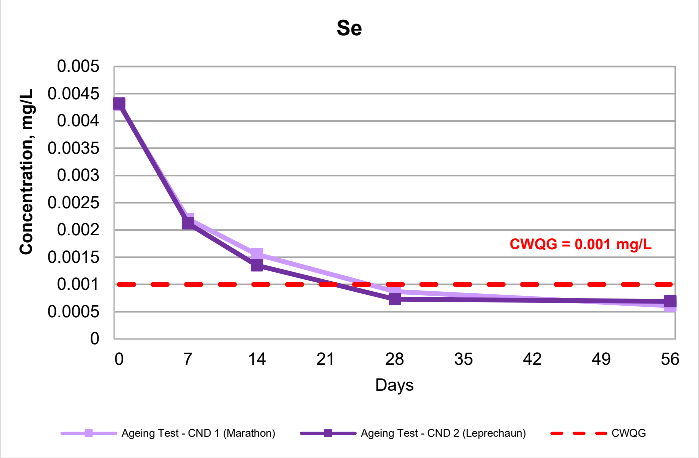


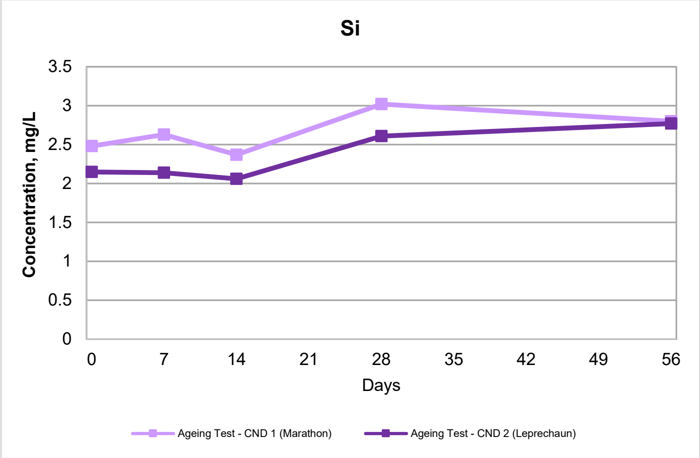


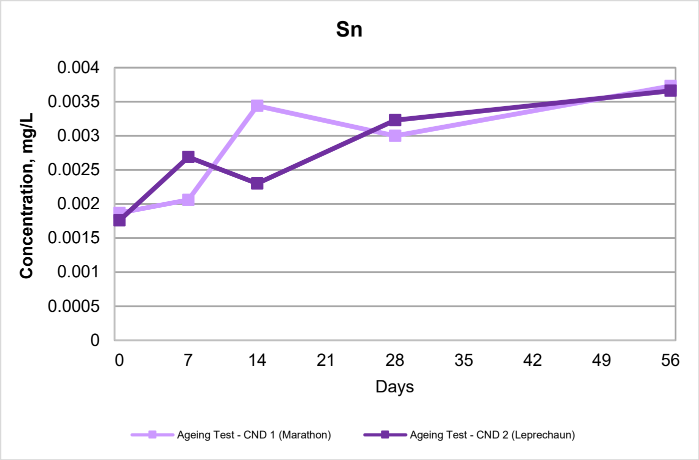


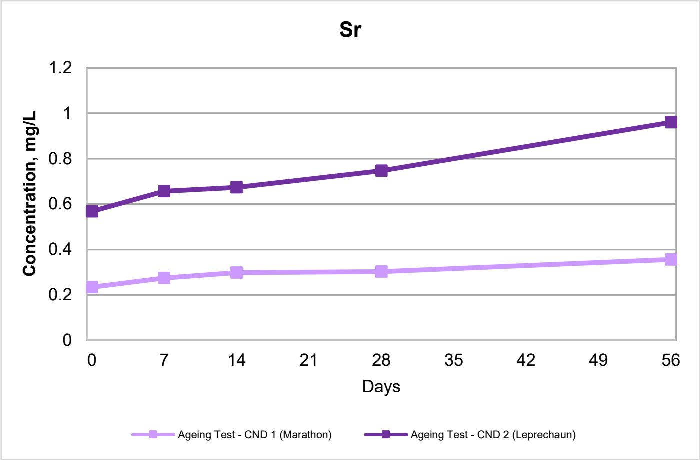






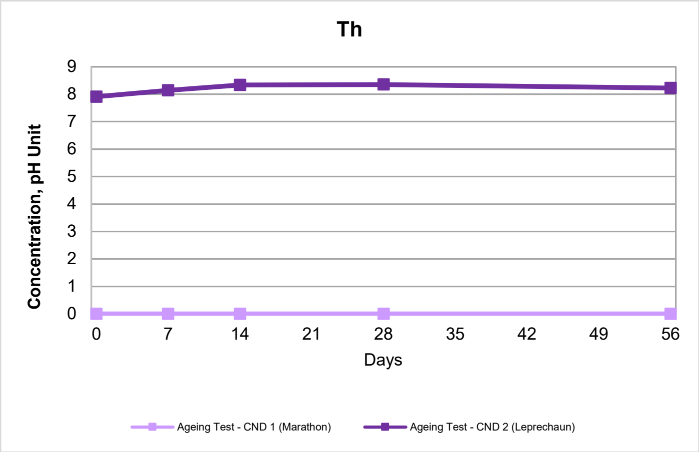


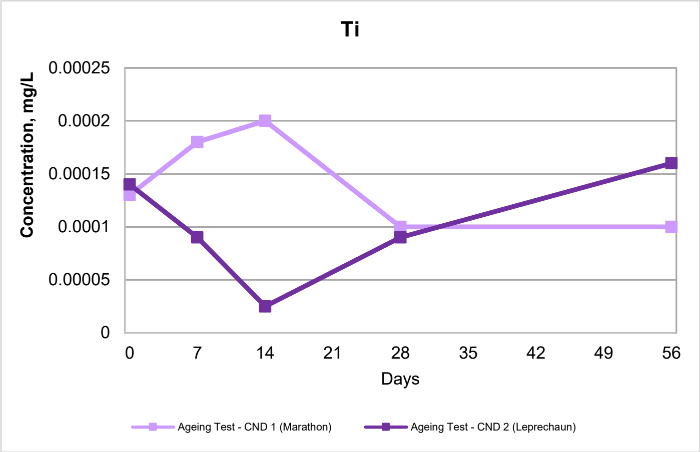


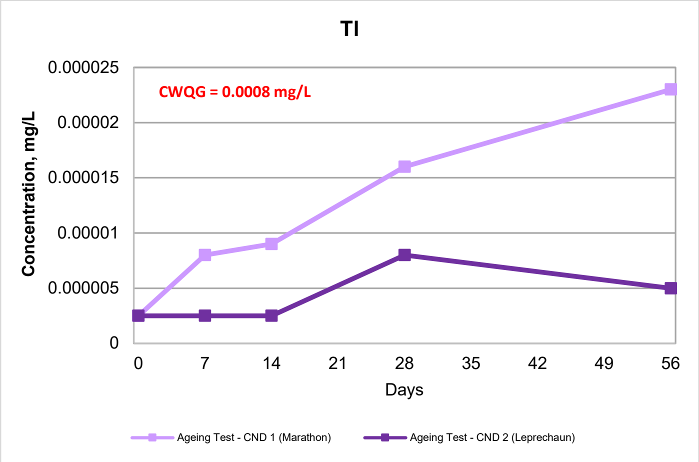


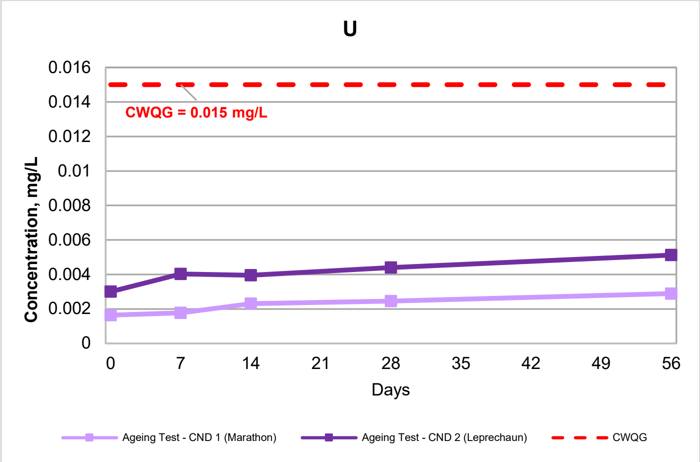
Note: Values below the respective detection limits (DLs) are shown as half DLs.

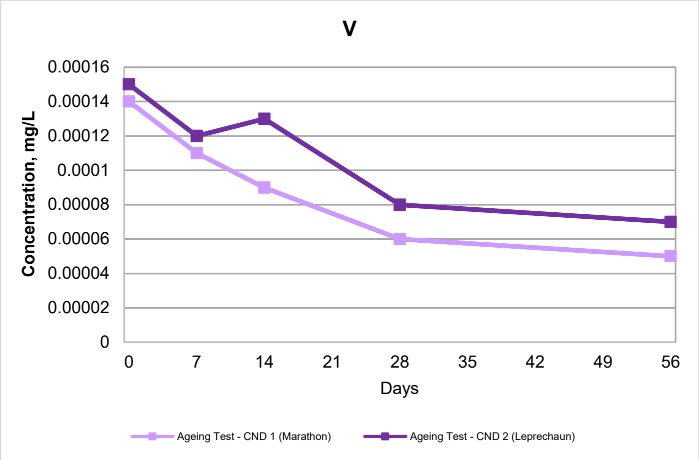
Marathon and Leprechaun process water ageing tests

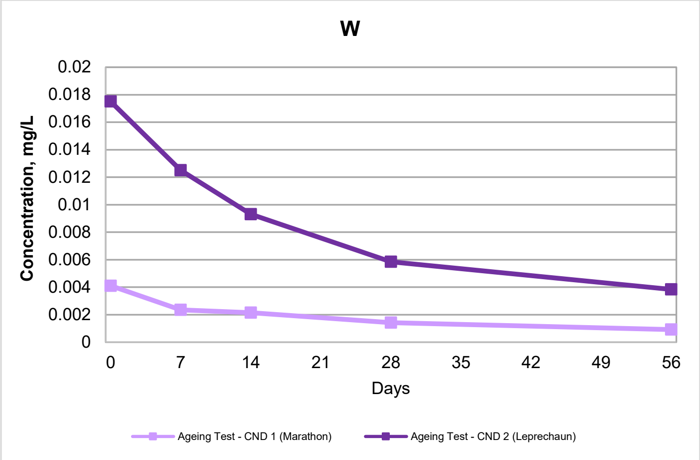


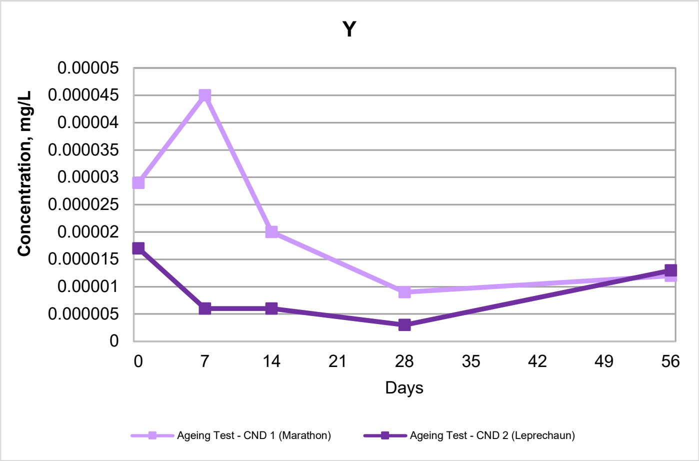


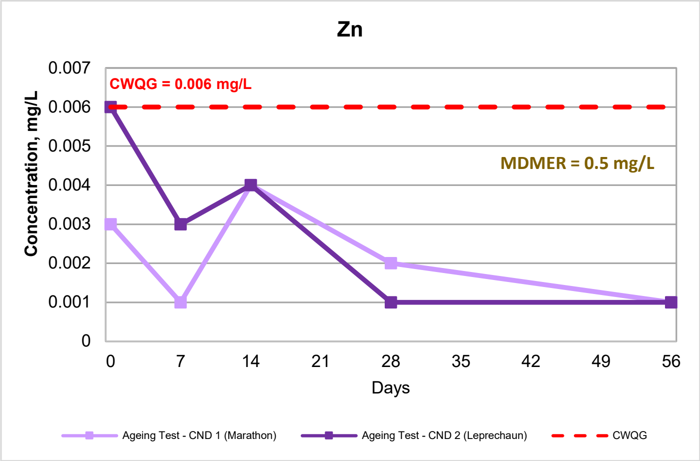












Note: Values below the respective detection limits (DLs) are shown as half DLs.

APPENDIX IR-21.A
KINETIC TESTING RESULTS

Test Specimen

Sample	Weight (g)
CND 1 Residue CNP DPL	1000

Analysis of Weekly Humidity Cell Leachate

Parameter	Units	CCME FAL	MDMER	0	1	2	3	4	5	6	7	8	9	10
Date			Effective	12-Aug-20	19-Aug-20	26-Aug-20	02-Sep-20	09-Sep-20	16-Sep-20	23-Sep-20	30-Sep-20	07-Oct-20	14-Oct-20	21-Oct-20
LIMS			01-Jun-2021	10106-AUG20	10145-AUG20	10223-AUG20	10008-SEP20	10092-SEP20	10154-SEP20	10233-SEP20	10315-SEP20	10022-OCT20	10133-OCT20	10197-OCT20
Hum Cell Leachate Vol	mL	-	-	568	846	859	813	890	899	831	486	394	502	319
pH	no unit	6.0-9.5	-	**5.73**	**5.96**	**5.42**	**5.66**	**5.52**	**5.45**	**5.18**	**4.98**	**4.84**	**4.41**	**4.36**
Acidity	mg/L as $CaCO_3$	-	-	15	9	6	3	3	4	4	14	15	18	8
Alkalinity	mg/L as $CaCO_3$	-	-	2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Conductivity	µS/cm	-	-	110	32	42	54	54	71	85	66	68	177	61
SO_4	mg/L	-	-	33	10	15	24	21	28	48	31	28	74	19
F	mg/L	0.12	-	< 0.06	< 0.06	< 0.06	---	< 0.06	---	---	---	< 0.06	---	---
NH_3+NH_4	as N mg/L	-	-	0.1	<0.1	<0.1	---	<0.1	---	---	---	---	---	---
Un-Ionized NH_3	as N mg/L	0.020	0.50	0.000	0.000	0.000	---	0.000	---	---	---	---	---	---
CN_T	mg/L	-	0.50	0.004	0.002	0.002	---	< 0.002	---	---	---	< 0.002	---	---
CN_{WAD}	mg/L	0.005 as CNF	-	0.003	0.002	0.002	---	< 0.002	---	---	---	< 0.002	---	---
Hg	mg/L	0.000026	-	< 0.00001	< 0.00001	0.00001	---	< 0.00001	---	---	---	< 0.00001	---	---
Ag	mg/L	0.00025	-	< 0.00005	< 0.00005	< 0.00005	---	< 0.00005	---	---	---	< 0.00005	---	---
Al	mg/L	0.005@pH<6.5	-	0.001	0.016	0.002	---	0.006	---	---	---	**0.077**	---	---
As	mg/L	0.005	0.10	< 0.0002	< 0.0002	< 0.0002	---	< 0.0002	---	---	---	0.0002	---	---
Ba	mg/L	-	-	0.00100	0.00074	0.00031	---	0.00140	---	---	---	0.00470	---	---
Be	mg/L	-	-	< 0.000007	< 0.000007	< 0.000007	---	< 0.000007	---	---	---	0.000034	---	---
B	mg/L	1.5	-	0.011	0.010	0.004	---	0.009	---	---	---	0.007	---	---
Bi	mg/L	-	-	< 0.000007	< 0.000007	0.000024	---	< 0.000007	---	---	---	< 0.000007	---	---
Ca	mg/L	-	-	10.1	3.03	4.18	---	6.32	---	---	---	6.74	---	---
Cd	mg/L	0.00009	-	0.000043	0.000004	0.000026	---	0.000050	---	---	---	**0.000283**	---	---
Co	mg/L	-	-	0.00113	0.000272	0.000743	---	0.00218	---	---	---	0.00648	---	---
Cr	mg/L	-	-	< 0.00008	< 0.00008	< 0.00008	---	< 0.00008	---	---	---	< 0.00008	---	---
Cu	mg/L	0.002	0.10	**0.0024**	0.0003	0.0009	---	**0.0028**	---	---	---	**0.0388**	---	---
Fe	mg/L	0.3	-	< 0.007	< 0.007	0.011	---	0.007	---	---	---	0.147	---	---
K	mg/L	-	-	0.322	0.335	0.052	---	0.088	---	---	---	0.081	---	---
Li	mg/L	-	-	0.0009	0.0011	0.0003	---	0.0004	---	---	---	0.0007	---	---
Mg	mg/L	-	-	3.76	0.926	1.24	---	1.52	---	---	---	1.33	---	---
Mn	mg/L	-	-	0.227	0.0657	0.117	---	0.159	---	---	---	0.198	---	---
Mo	mg/L	0.073	-	< 0.00004	0.00091	< 0.00004	---	0.00011	---	---	---	< 0.00004	---	---
Na	mg/L	-	-	2.61	2.98	0.52	---	0.51	---	---	---	0.48	---	---
Ni	mg/L	0.03	0.25	0.0021	0.0005	0.0013	---	0.0037	---	---	---	0.0133	---	---
P	mg/L	-	-	0.019	< 0.003	< 0.003	---	< 0.003	---	---	---	< 0.003	---	---
Pb	mg/L	0.001	0.08	0.00008	< 0.00001	< 0.00001	---	0.00003	---	---	---	0.00027	---	---
Sb	mg/L	-	-	0.0009	< 0.0009	< 0.0009	---	< 0.0009	---	---	---	< 0.0009	---	---
Se	mg/L	0.001	-	0.00034	0.00007	0.00009	---	0.00008	---	---	---	0.00009	---	---
Si	mg/L	-	-	0.89	0.33	0.40	---	0.57	---	---	---	0.88	---	---
Sn	mg/L	-	-	0.00034	0.00006	0.00024	---	< 0.00006	---	---	---	0.00006	---	---
Sr	mg/L	-	-	0.00887	0.0330	0.00312	---	0.00636	---	---	---	0.0126	---	---
Th	mg/L	-	-	< 0.0001	< 0.0001	< 0.0001	---	< 0.0001	---	---	---	< 0.0001	---	---
Ti	mg/L	-	-	< 0.00005	< 0.00005	< 0.00005	---	< 0.00005	---	---	---	< 0.00005	---	---
Tl	mg/L	0.0008	-	< 0.000005	< 0.000005	< 0.000005	---	< 0.000005	---	---	---	< 0.000005	---	---
U	mg/L	0.015	-	< 0.000002	0.000004	< 0.000002	---	< 0.000002	---	---	---	0.000034	---	---
V	mg/L	-	-	< 0.00001	0.00002	< 0.00001	---	< 0.00001	---	---	---	< 0.00001	---	---
W	mg/L	-	-	0.00005	0.00009	< 0.00002	---	< 0.00002	---	---	---	0.00025	---	---
Y	mg/L	-	-	0.000016	< 0.000002	0.000006	---	0.000066	---	---	---	0.000901	---	---
Zn	mg/L	0.007	0.40	**0.016**	0.003	0.008	---	**0.019**	---	---	---	**0.064**	---	---

Test Specimen

Sample	Weight (g)
CND 1 Residue CNP DPL	1000

Analysis of Weekly Humidity Cell Leachate

Parameter	Units	CCME FAL	MDMER	11	12	13	14	15	16	17	18	19	20	21
Date			Effective	28-Oct-20	04-Nov-20	11-Nov-20	18-Nov-20	25-Nov-20	02-Dec-20	09-Dec-20	16-Dec-20	23-Dec-20	30-Dec-20	06-Jan-21
LIMS			01-Jun-2021	10255-OCT20	10020-NOV20	10078-NOV20	10125-NOV20	10163-NOV20	10019-DEC20	10071-DEC20	10163-DEC20	10186-DEC20	10241-DEC20	10026-JAN21
Hum Cell Leachate Vol	mL	-	-	673	755	420	304	308	298	289	353	282	250	304
pH	no unit	6.0-9.5	-	**4.28**	**4.02**	**3.70**	**3.76**	**3.21**	**3.02**	**2.98**	**2.84**	**2.73**	**2.70**	**2.75**
Acidity	mg/L as $CaCO_3$	-	-	14	49	101	112	174	198	373	454	547	585	556
Alkalinity	mg/L as $CaCO_3$	-	-	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Conductivity	µS/cm	-	-	243	336	561	498	602	691	970	1160	1400	1460	1380
SO_4	mg/L	-	-	100	130	240	180	220	290	420	470	630	650	560
F	mg/L	0.12	-	---	**0.29**	---	---	---	**0.21**	---	---	---	**0.16**	---
NH_3+NH_4	as N mg/L	-	-	---	---	---	---	---	---	---	---	---	---	---
Un-Ionized NH_3	as N mg/L	0.020	0.50	---	---	---	---	---	---	---	---	---	---	---
CN_T	mg/L	-	0.50	---	< 0.002	---	---	---	< 0.002	---	---	---	< 0.002	---
CN_{WAD}	mg/L	0.005 as CNF	-	---	< 0.002	---	---	---	< 0.002	---	---	---	0.002	---
Hg	mg/L	0.000026	-	---	< 0.00001	---	---	---	< 0.00001	---	---	---	< 0.00001	---
Ag	mg/L	0.00025	-	---	< 0.00005	---	---	---	< 0.00005	---	---	---	0.00005	---
Al	mg/L	0.005@pH<6.5	-	---	**4.50**	---	---	---	**27.8**	---	---	---	**51.8**	---
As	mg/L	0.005	0.10	---	0.0038	---	---	---	0.0043	---	---	---	0.0046	---
Ba	mg/L	-	-	---	0.0338	---	---	---	0.0637	---	---	---	0.0555	---
Be	mg/L	-	-	---	0.000852	---	---	---	0.00236	---	---	---	0.00233	---
B	mg/L	1.5	-	---	0.004	---	---	---	0.004	---	---	---	0.007	---
Bi	mg/L	-	-	---	< 0.000007	---	---	---	< 0.000007	---	---	---	0.000080	---
Ca	mg/L	-	-	---	14.4	---	---	---	11.1	---	---	---	5.10	---
Cd	mg/L	0.00009	-	---	**0.00454**	---	---	---	**0.00459**	---	---	---	**0.00530**	---
Co	mg/L	-	-	---	0.0851	---	---	---	0.0567	---	---	---	0.0901	---
Cr	mg/L	-	-	---	0.00073	---	---	---	0.0276	---	---	---	0.166	---
Cu	mg/L	0.002	0.10	---	**0.688**	---	---	---	**1.67**	---	---	---	**1.20**	---
Fe	mg/L	0.3	-	---	**3.06**	---	---	---	**13.9**	---	---	---	**69.3**	---
K	mg/L	-	-	---	0.612	---	---	---	0.853	---	---	---	0.830	---
Li	mg/L	-	-	---	0.0072	---	---	---	0.0083	---	---	---	0.0295	---
Mg	mg/L	-	-	---	13.6	---	---	---	4.36	---	---	---	10.1	---
Mn	mg/L	-	-	---	1.83	---	---	---	0.506	---	---	---	0.727	---
Mo	mg/L	0.073	-	---	0.00024	---	---	---	0.00022	---	---	---	0.00031	---
Na	mg/L	-	-	---	4.79	---	---	---	3.75	---	---	---	4.71	---
Ni	mg/L	0.03	0.25	---	**0.187**	---	---	---	**0.0906**	---	---	---	**0.0997**	---
P	mg/L	-	-	---	< 0.003	---	---	---	< 0.003	---	---	---	< 0.003	---
Pb	mg/L	0.001	0.08	---	**0.00138**	---	---	---	**0.0134**	---	---	---	**0.0580**	---
Sb	mg/L	-	-	---	< 0.0009	---	---	---	< 0.0009	---	---	---	0.0011	---
Se	mg/L	0.001	-	---	0.00093	---	---	---	**0.00105**	---	---	---	0.00085	---
Si	mg/L	-	-	---	3.84	---	---	---	15.4	---	---	---	18.5	---
Sn	mg/L	-	-	---	0.00007	---	---	---	0.00016	---	---	---	0.00041	---
Sr	mg/L	-	-	---	0.0501	---	---	---	0.0378	---	---	---	0.0266	---
Th	mg/L	-	-	---	< 0.0001	---	---	---	0.0028	---	---	---	0.0108	---
Ti	mg/L	-	-	---	0.00008	---	---	---	< 0.00005	---	---	---	0.00014	---
Tl	mg/L	0.0008	-	---	< 0.000005	---	---	---	< 0.000005	---	---	---	< 0.000005	---
U	mg/L	0.015	-	---	0.00105	---	---	---	0.00328	---	---	---	0.00420	---
V	mg/L	-	-	---	0.00002	---	---	---	< 0.00001	---	---	---	0.00025	---
W	mg/L	-	-	---	0.00054	---	---	---	0.00006	---	---	---	0.00055	---
Y	mg/L	-	-	---	0.0365	---	---	---	0.105	---	---	---	0.0851	---
Zn	mg/L	0.007	0.40	---	**0.793**	---	---	---	**0.603**	---	---	---	**0.606**	---

Test Specimen

Sample	Weight (g)
CND 1 Residue CNP DPL	1000

Analysis of Weekly Humidity Cell Leachate

Parameter	Units	CCME FAL	MDMER	22	23	24	25
Date			Effective	13-Jan-21	20-Jan-21	27-Jan-21	03-Feb-21
LIMS			01-Jun-2021	10067-JAN21	10143-JAN21	10208-JAN21	10019-FEB21
Hum Cell Leachate Vol	mL	-	-	307	398	372	302
pH	no unit	6.0-9.5	-	**2.71**	**2.74**	**2.77**	**2.69**
Acidity	mg/L as CaCO$_3$	-	-	589	492	450	468
Alkalinity	mg/L as CaCO$_3$	-	-	< 2	< 2	< 2	< 2
Conductivity	µS/cm	-	-	1510	1330	1320	1400
SO$_4$	mg/L	-	-	660	520	500	540
F	mg/L	0.12	-	---	---	< 0.06	---
NH$_3$+NH$_4$	as N mg/L	-	-	---	---	---	---
Un-Ionized NH$_3$	as N mg/L	0.020	0.50	---	---	---	---
CN$_T$	mg/L	-	0.50	---	---	< 0.002	---
CN$_{WAD}$	mg/L	0.005 as CNF	-	---	---	< 0.002	---
Hg	mg/L	0.000026	-	---	---	< 0.00001	---
Ag	mg/L	0.00025	-	---	---	< 0.00005	---
Al	mg/L	0.005@pH<6.5	-	---	---	**37.6**	---
As	mg/L	0.005	0.10	---	---	0.0026	---
Ba	mg/L	-	-	---	---	0.0398	---
Be	mg/L	-	-	---	---	0.00117	---
B	mg/L	1.5	-	---	---	0.003	---
Bi	mg/L	-	-	---	---	< 0.000007	---
Ca	mg/L	-	-	---	---	4.60	---
Cd	mg/L	0.00009	-	---	---	**0.00399**	---
Co	mg/L	-	-	---	---	0.0616	---
Cr	mg/L	-	-	---	---	0.110	---
Cu	mg/L	0.002	0.10	---	---	**0.558**	---
Fe	mg/L	0.3	-	---	---	**59.7**	---
K	mg/L	-	-	---	---	0.544	---
Li	mg/L	-	-	---	---	0.0126	---
Mg	mg/L	-	-	---	---	6.89	---
Mn	mg/L	-	-	---	---	0.543	---
Mo	mg/L	0.073	-	---	---	0.00012	---
Na	mg/L	-	-	---	---	3.11	---
Ni	mg/L	0.03	0.25	---	---	**0.0639**	---
P	mg/L	-	-	---	---	< 0.003	---
Pb	mg/L	0.001	0.08	---	---	**0.0574**	---
Sb	mg/L	-	-	---	---	< 0.0009	---
Se	mg/L	0.001	-	---	---	0.00059	---
Si	mg/L	-	-	---	---	32.5	---
Sn	mg/L	-	-	---	---	0.00026	---
Sr	mg/L	-	-	---	---	0.0184	---
Th	mg/L	-	-	---	---	0.0111	---
Ti	mg/L	-	-	---	---	0.00020	---
Tl	mg/L	0.0008	-	---	---	< 0.000005	---
U	mg/L	0.015	-	---	---	0.00191	---
V	mg/L	-	-	---	---	0.00029	---
W	mg/L	-	-	---	---	0.00005	---
Y	mg/L	-	-	---	---	0.0389	---
Zn	mg/L	0.007	0.40	---	---	**0.332**	---

TEST REPORT

Humidity Cell Test (ASTM D 5744-96)

Test Specimen

Sample	Weight (g)
CND 1 Residue CNP DPL	1000

Summary of ABA Test Data

Parameter	Units	Ref No.: 10141-JUL20
Sulphur (S)	%	0.408
Sulphide ($S^{=}$)	%	0.42
NP	t $CaCO_3$/1000 t	3.5
CO_3 NP	t $CaCO_3$/1000 t	3.3

Leachate Parameters Measured							***Acid Generation*** [1]				***Acid Neutralization*** [1]		
Weekly Leach No.	**Volume Collected** mL	**pH** units	**Acidity** $CaCO_3$ eq. mg/L	**Alkalinity** $CaCO_3$ eq. mg/L	**Conductivity** µS/cm	**SO_4** mg/L	**SO_4 Production Rate** g/t/wk	**Cumulative SO_4 Production** g/t	**Weekly $S^{=}$ Depletion** %	**Cumulative $S^{=}$ Depletion** %	**NP Consumption** $CaCO_3$, g/t/wk	**Cumulative NP Depletion** %	**Cumulative CO_3 NP Depletion** %
0	568	5.73	15	2	110	33	18.7	18.7	0.15	0.15	19.53	0.56	0.59
1	846	5.96	9	<2	32	10	8.5	27.2	0.07	0.22	8.81	0.81	0.86
2	859	5.42	6	<2	42	15	12.9	40.1	0.10	0.32	13.42	1.19	1.27
3	813	5.66	3	<2	54	24	19.5	59.6	0.15	0.47	20.33	1.77	1.88
4	890	5.52	3	<2	54	21	18.7	78.3	0.15	0.62	19.47	2.33	2.47
5	899	5.45	4	<2	71	28	25.2	103.5	0.20	0.82	26.22	3.08	3.27
6	831	5.18	4	<2	85	48	39.9	143.4	0.32	1.14	41.55	4.27	4.52
7	486	4.98	14	<2	66	31	15.1	158.4	0.12	1.26	15.69	4.71	5.00
8	394	4.84	15	<2	68	28	11.0	169.4	0.09	1.34	11.49	5.04	5.35
9	502	4.41	18	<2	177	74	37.1	206.6	0.29	1.64	38.70	6.15	6.52
10	319	4.36	8	<2	61	19	6.1	212.7	0.05	1.69	6.31	6.33	6.71
11	673	4.28	14	<2	243	100	67.3	280.0	0.53	2.22	70.10	8.33	8.84
12	755	4.02	49	<2	336	130	98.2	378.1	0.78	3.00	102.24	11.25	11.94
13	420	3.70	101	<2	561	240	100.8	478.9	0.80	3.80	105.00	14.25	15.12
14	304	3.76	112	<2	498	180	54.7	533.6	0.43	4.24	57.00	15.88	16.84
15	308	3.21	174	<2	602	220	67.8	601.4	0.54	4.77	70.58	17.90	18.98
16	298	3.02	198	<2	691	290	86.4	687.8	0.69	5.46	90.02	20.47	21.71
17	289	2.98	373	<2	970	420	121.4	809.2	0.96	6.42	126.44	24.08	25.54
18	353	2.84	454	<2	1160	470	165.9	975.1	1.32	7.74	172.82	29.02	30.78
19	282	2.73	547	<2	1400	630	177.7	1152.8	1.41	9.15	185.06	34.31	36.39
20	250	2.70	585	<2	1460	650	162.5	1315.3	1.29	10.44	169.27	39.14	41.52

** Initial Week 0 leachate may included soluble sulphate, and may not indicate oxidation of sulphide in the sample material has occurred.*

[1] *Calculated values*

Summary - Weeks 0 to 20

Maximum Value	5.96	585	2	1460	650	177.7	-	1.41	-	185.06	-	-
Minimum Value	2.70	3	<2	32	10	6.1	-	0.05	-	6.31	-	-
Average Value	3.39	129	2	416	174	62.6	-	0.50	-	65.24	-	-

TEST REPORT

Humidity Cell Test (ASTM D 5744-96)

Test Specimen

Sample	Weight (g)
CND 1 Residue CNP DPL	1000

Changes to Head Sample after 20 Weeks[1]

Parameter	Units	Ref No.: 10141-JUL20
Sulphide ($S^=$) Remaining	%	0.38
NP Remaining	t $CaCO_3$/1000 t	2.1
CO_3 NP Remaining	t $CaCO_3$/1000 t	1.9

Leachate Parameters Measured							*Acid Generation*[1]				*Acid Neutralization*[1]		
Weekly Leach No.	**Volume Collected** mL	**pH** units	**Acidity** $CaCO_3$ eq. mg/L	**Alkalinity** $CaCO_3$ eq. mg/L	**Conductivity** µS/cm	**SO_4** mg/L	**SO_4 Production Rate** g/t/wk	**Cumulative SO_4 Production** g/t	**Weekly $S^=$ Depletion** %	**Cumulative $S^=$ Depletion** %	**NP Consumption** $CaCO_3$, g/t/wk	**Cumulative NP Depletion** %	**Cumulative CO_3 NP Depletion** %
21	304	2.75	556	<2	1380	560	170.2	1485.5	1.35	11.79	177.33	44.21	46.89
22	307	2.71	589	<2	1510	660	202.6	1688.1	1.61	13.40	211.06	50.24	53.29
23	398	2.74	492	<2	1330	520	207.0	1895.1	1.64	15.04	215.58	56.40	59.82
24	372	2.77	450	<2	1320	500	186.0	2081.1	1.48	16.52	193.75	61.94	65.69
25	302	2.69	468	<2	1400	540	163.1	2244.2	1.29	17.81	169.88	66.79	70.84

[1] *Calculated values*

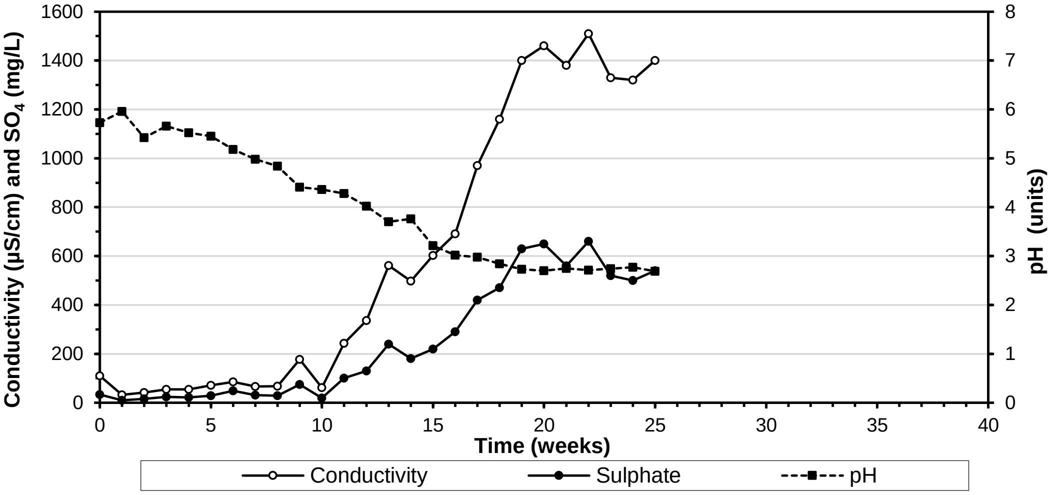
Summary - Weeks 0 to 40

	pH	Acidity	Alkalinity	Conductivity	SO_4	SO_4 Production Rate	Cumulative SO_4 Production	Weekly $S^=$ Depletion	Cumulative $S^=$ Depletion	NP Consumption	Cumulative NP Depletion	Cumulative CO_3 NP Depletion
Maximum Value	5.96	589	2	1510	660	207.0	-	1.64	-	216	-	-
Minimum Value	2.69	3	<2	32	10	6.1	-	0.05	-	6.3	-	-
Average Value	3.16	202	2	603	248	86.3	-	0.69	-	89.91	-	-

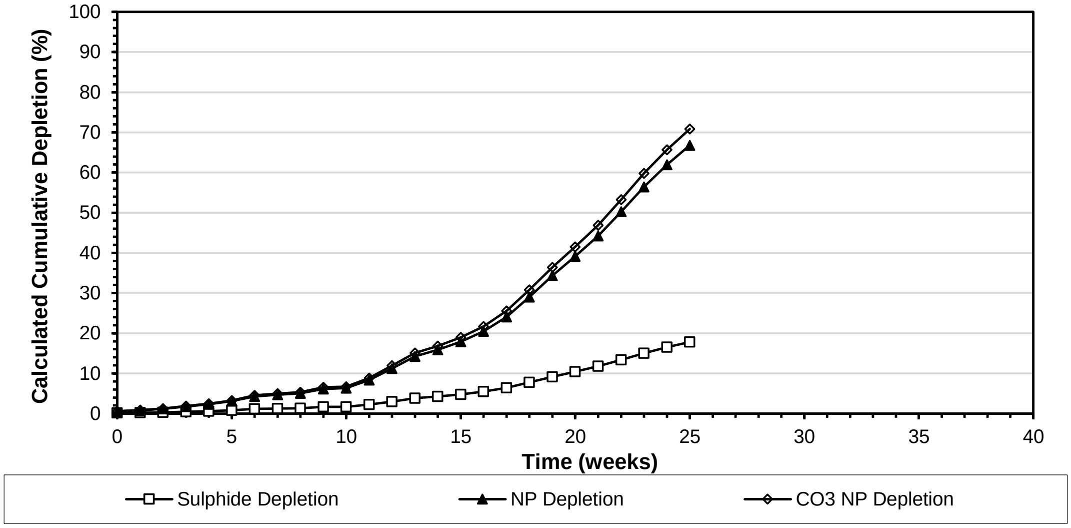
TEST REPORT

Humidity Cell Test (ASTM D 5744-96)

Conductivity, Sulphate, and pH in Weekly Humidity Cell Leachate - CND 1 Residue CNP DPL



Cumulative Sulphide and NP Depletion CND 1 Residue CNP DPL

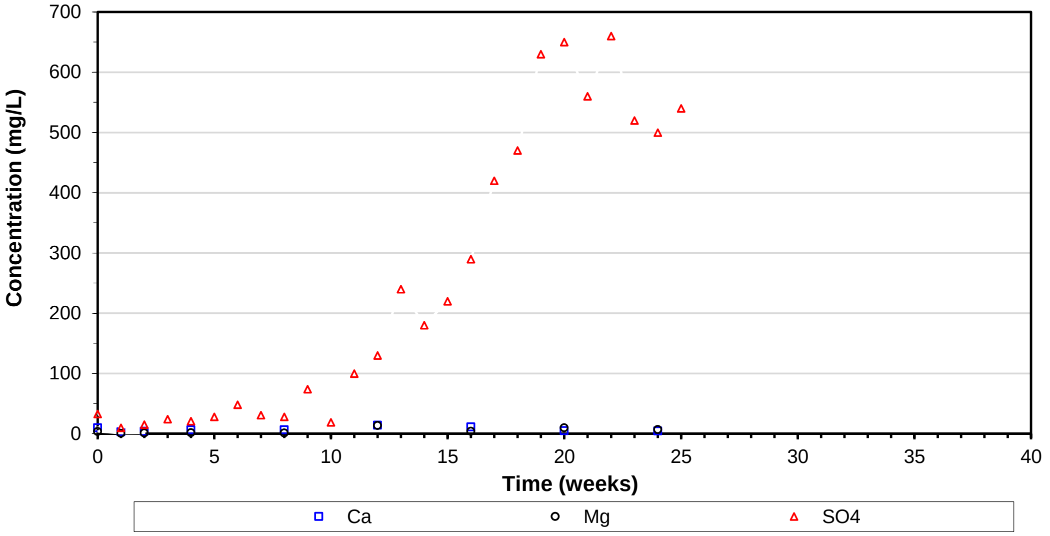


Note: NP depletion calculated based on sulphate assay.

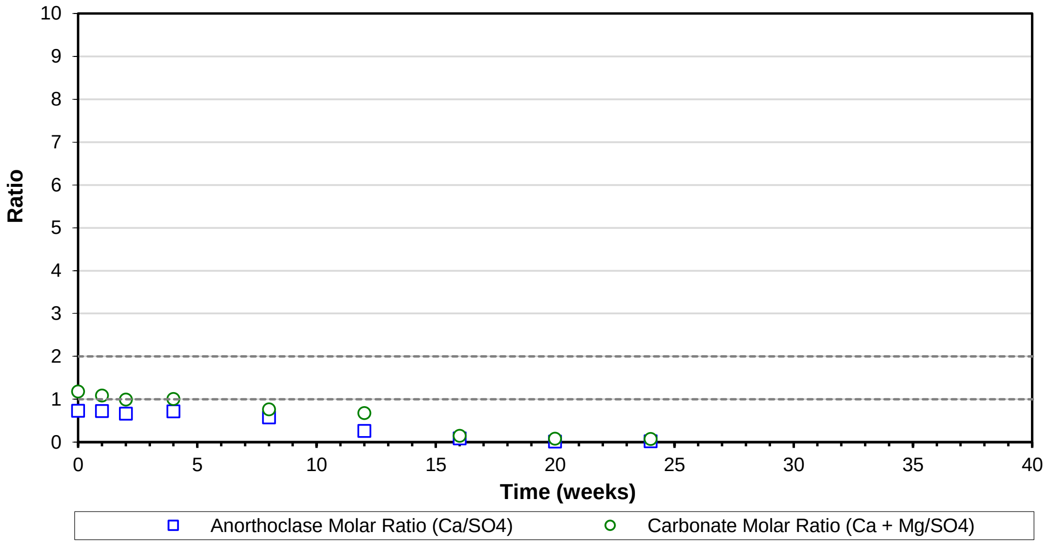
TEST REPORT

Humidity Cell Test (ASTM D 5744-96)

Selected Parameters in Weekly Humidity Cell Leachate CND 1 Residue CNP DPL



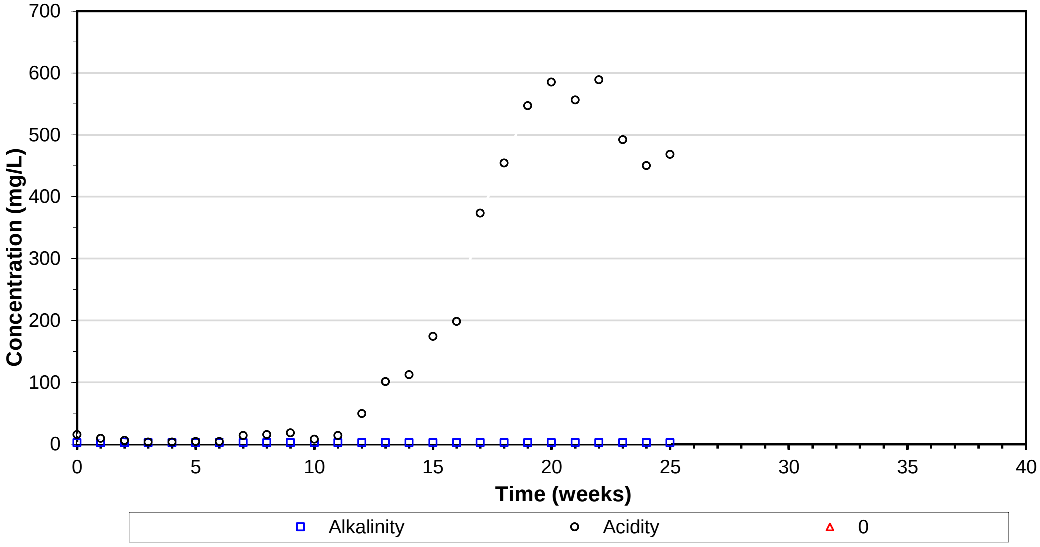
Carbonate (Ca + Mg/SO$_4$) and Anorthoclase (Ca/SO$_4$) Molar Ratios CND 1 Residue CNP DPL



TEST REPORT

Humidity Cell Test (ASTM D 5744-96)

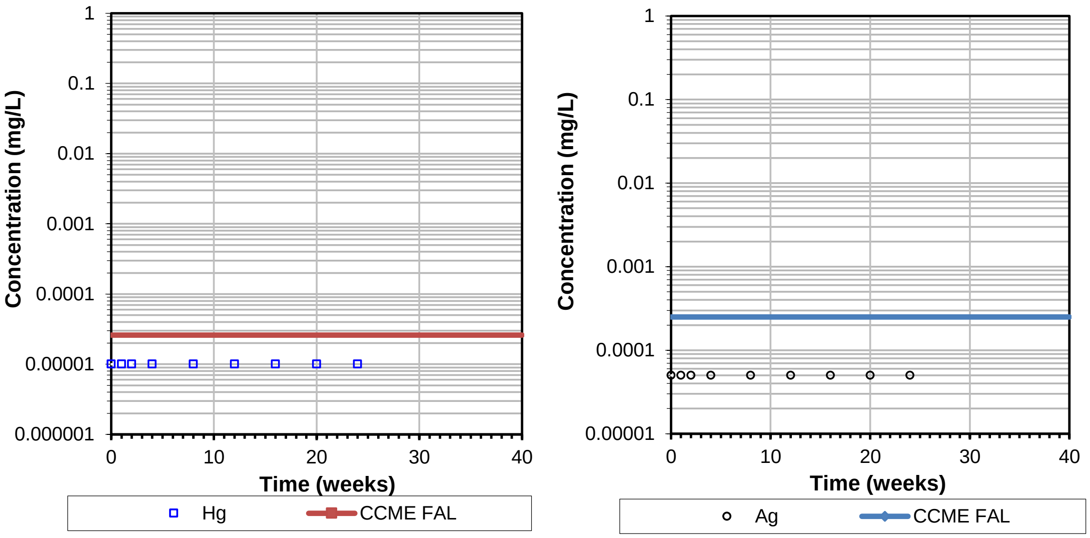
Selected Parameters in Weekly Humidity Cell Leachate CND 1 Residue CNP DPL



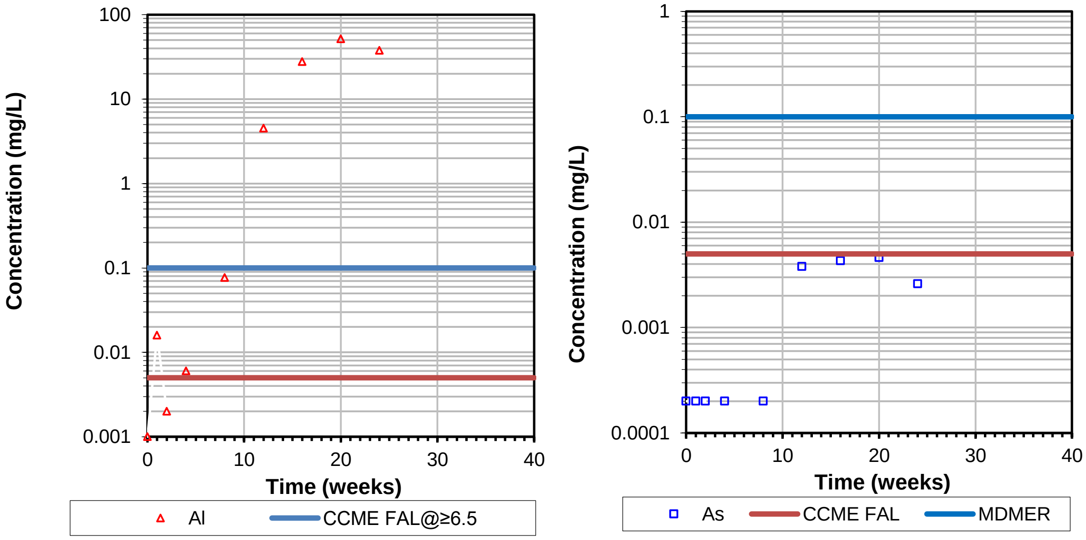
TEST REPORT

Humidity Cell Test (ASTM D 5744-96)

Selected Parameters in Weekly Humidity Cell Leachate CND 1 Residue CNP DPL



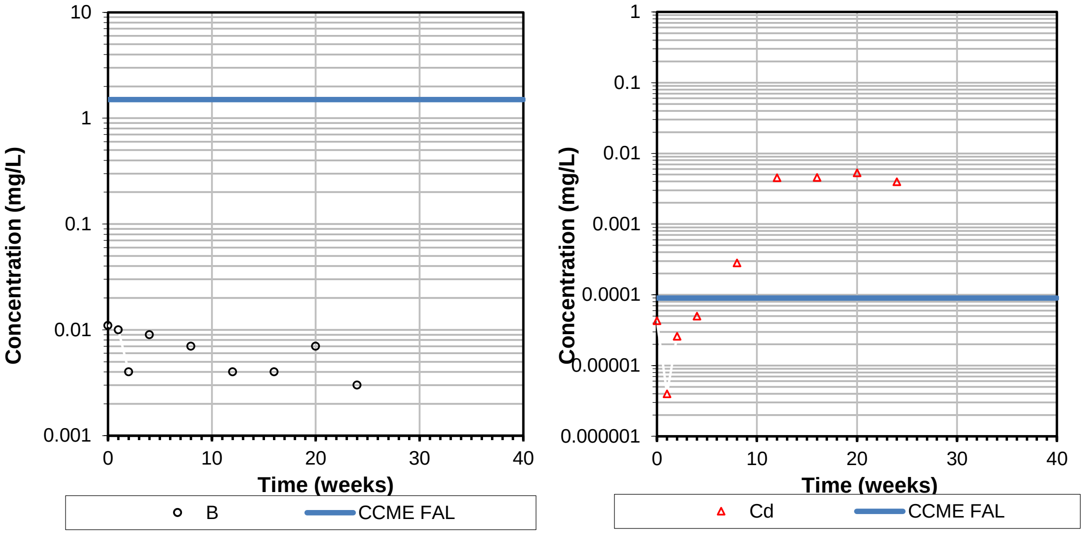
Selected Parameters in Weekly Humidity Cell Leachate CND 1 Residue CNP DPL



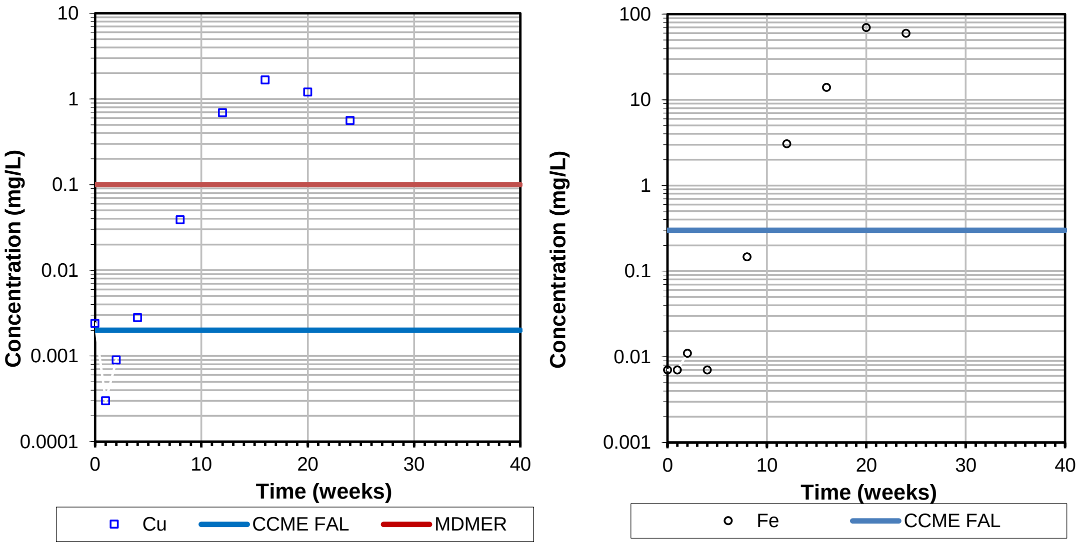
TEST REPORT

Humidity Cell Test (ASTM D 5744-96)

Selected Parameters in Weekly Humidity Cell Leachate CND 1 Residue CNP DPL



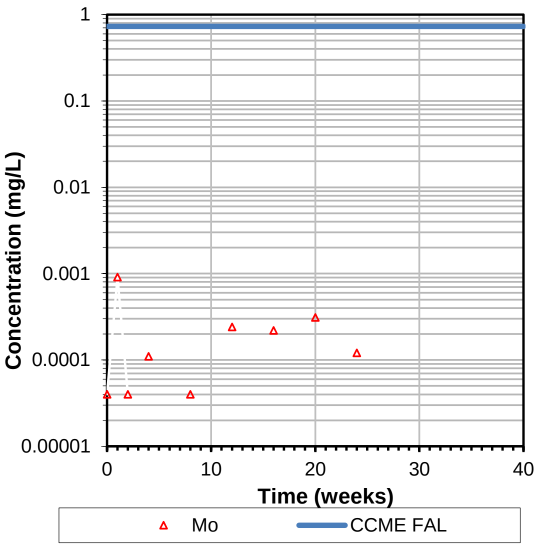
Selected Parameters in Weekly Humidity Cell Leachate CND 1 Residue CNP DPL

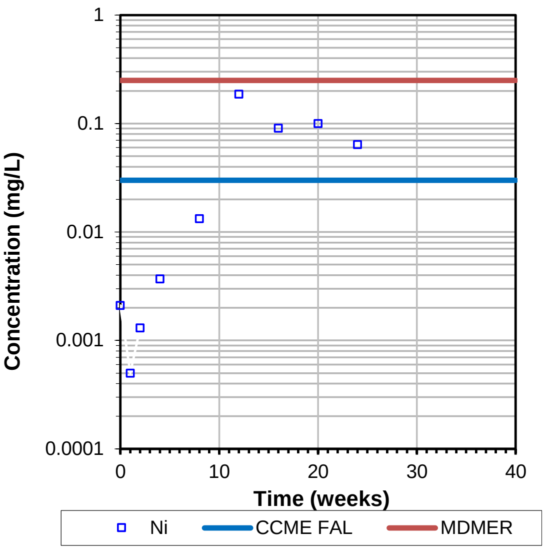


TEST REPORT

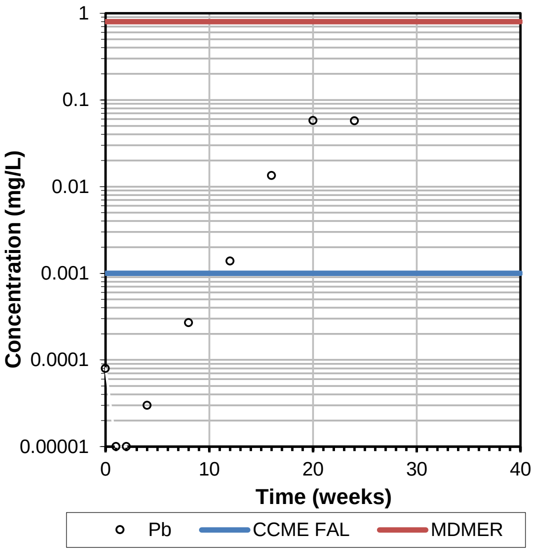
Humidity Cell Test (ASTM D 5744-96)

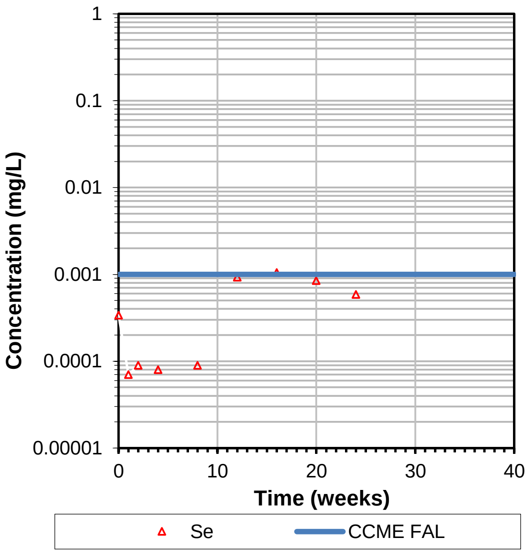
Selected Parameters in Weekly Humidity Cell Leachate CND 1 Residue CNP DPL





Selected Parameters in Weekly Humidity Cell Leachate CND 1 Residue CNP DPL

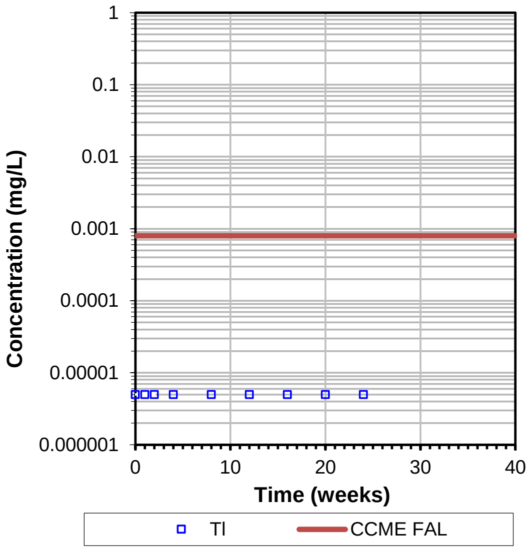


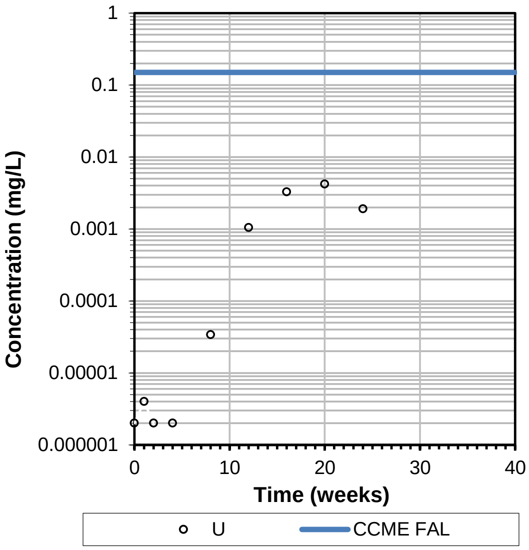


TEST REPORT

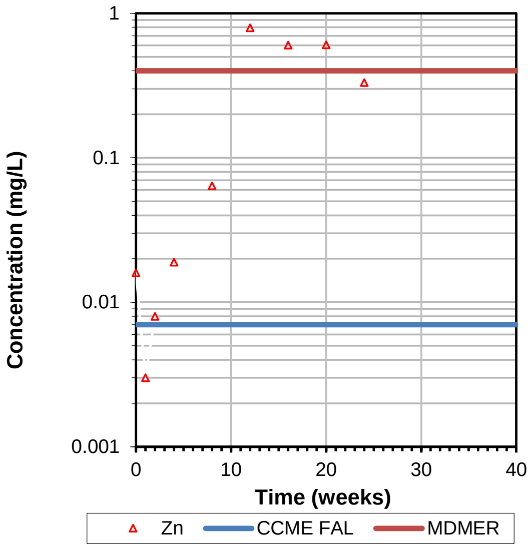
Humidity Cell Test (ASTM D 5744-96)

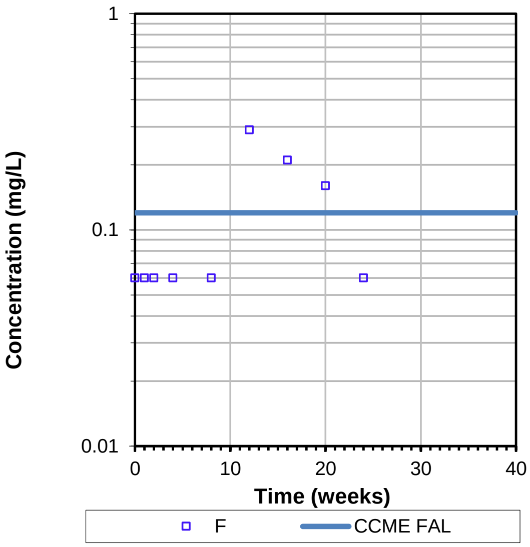
Selected Parameters in Weekly Humidity Cell Leachate CND 1 Residue CNP DPL





Selected Parameters in Weekly Humidity Cell Leachate CND 1 Residue CNP DPL





APPENDIX IR-21.B
ARD ONSET

Appendix IR-21.B

Model Sensitivity to Acid Rock Drainage (ARD) Lag Time

Natural Resources Canada (NRCan), in IR-21, requested that Marathon "provide rationale for the methods used to determine the lag time to acidic conditions, and a discussion around the sensitivity of the water quality model to the assumptions related to this assumed lag time". In a call on (March 22, 2021), NRCan expressed concerns about estimates of lag time to acidic conditions without kinetic tests being conducted on several potentially acid generating (PAG) samples. The objectives of this memorandum are to:

- provide rationale for the methods used to determine the lag time to acidic conditions and estimate on the possible ranges of ARD onset lag time for exposed PAG materials
- assess and discuss sensitivity of the water quality model to ranges of ARD onset lag time

ARD Onset Time

The determination of the lag time to acidic conditions is based on Equations (1) and (2), which are consistent with the Mine Environment Neutral Drainage (MEND) Manual (2009).

Neutralization Potential (NP) Depletion Rate = Sulphate Leaching Rate*100.09/96.06 + Alkalinity Production Rate – Acidity Production Rate (1)

ARD onset time = (Carb. NP/ NP Depletion Rate) x 1000/(365.25/7) (2)

The following steps were used to derive conservative inputs from existing humidity cell tests (HCT) tests for use in Equations (1) and (2).

a. Leaching rates calculation

Sulphate leaching and alkalinity production rates are required for inputs into Equation 1. These rates are straight calculations from laboratory humidity cell testing results without any scaling to field conditions. The calculation of sulphate leaching rate for a specific week is shown as an example in Equation 3:

Sulphate Leaching Rate (mg/kg/week) = Sulphate Concentration (mg/L) x Leachate volume (L)/Samples mass (1kg)/Leaching time (1 week) (3)

The maximum concentrations from the first month (weeks 1 to 4) of testing were used as inputs to Equation 3 resulting in the highest sulphate leaching rates listed in Table 1 (attached). The highest sulphate production and NP depletion rates using direct HCT data result in the shortest lag time estimates for ARD, which is a conservative approach.

b. Leaching rate regressions with sulfur and NP

The next step was to evaluate the correlation between maxima sulphate and maxima alkalinity leaching rates with sulphur contents and NPs, respectively.

A linear regression for maximum sulphate leaching rates versus sulphur contents results in a R^2 considered to be acceptable for general predictive use. Note that the reported R^2 was obtained after removal of one outlier, sample M MD (Figure 1). This sample showed an order of magnitude higher sulphate production rate likely due to over crushing of the sample resulting in higher reactive surface area. The regression equation (Equation 4) was used to estimate sulphate leaching rates from PAG samples with known sulphur content, which are provided in Table 2 (attached). A similar approach has been presented in Environmental Impact Statements (EISs) for other Canadian mine projects (e.g., SRK 2006, 2013).

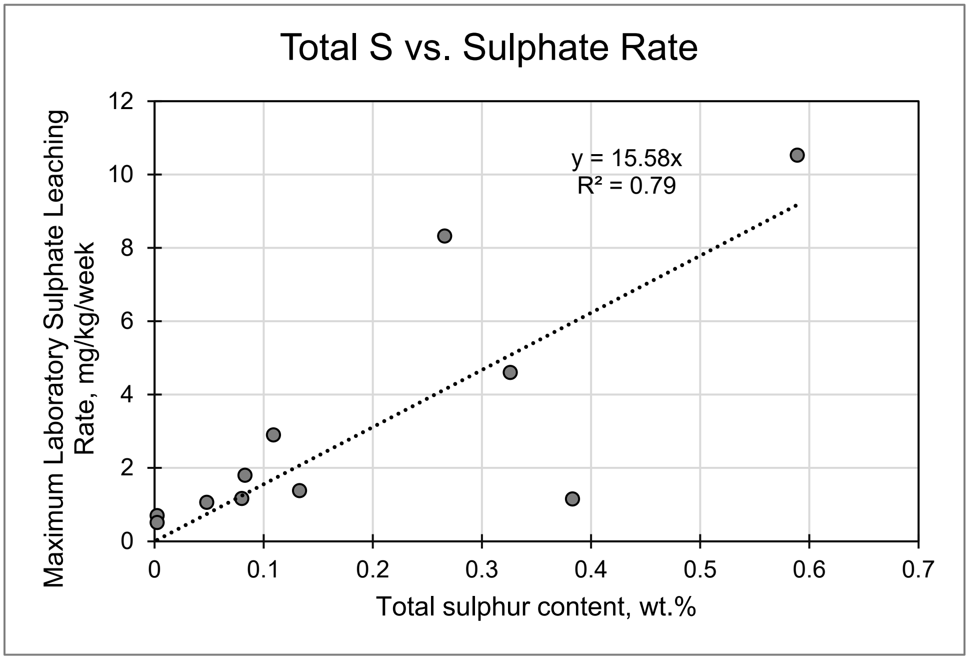


Figure 1. Regression of total sulphur vs. maximum sulphate leaching rate from laboratory humidity cells.

Sulphate Leaching Rate (mg/kg/week) = 15.6*Sulphur Content (wt%) (4)

Maximum alkalinity leaching rates show poor correlation with NP even after removal of apparent outliers shown in red on Figure 2. Therefore, the 95th percentile of maximum alkalinity leaching rates (67.7 $mgCaCO_3$/kg/week) was conservatively selected for input into Equation 1 regardless of NP of the PAG sample.

The Acidity Production Rate was ignored in Equation 1 resulting in shorter lag time estimates for ARD, which is a an additionally conservative assumption. Considering the inputs and assumptions discussed above, the resulting calculation of NP depletion rate for each PAG sample was done using Equation 5.

NP Depletion Rate ($mgCaCO_3$/kg/week) = 15.6*Sulphur Content (wt%)*100.09/96.06 + 67.7 (5)

Examination of the sulphur inputs to this equation clearly shows than the first term of Equation 5 is an order of magnitude lower than the second term, alkalinity production rate. The second term is a constant and the NP Depletion Rate does not vary much between samples as shown in Table 2 (attached). Therefore, the NP of a sample becomes the key factor determining ARD onset time in the sample per Equation 2.

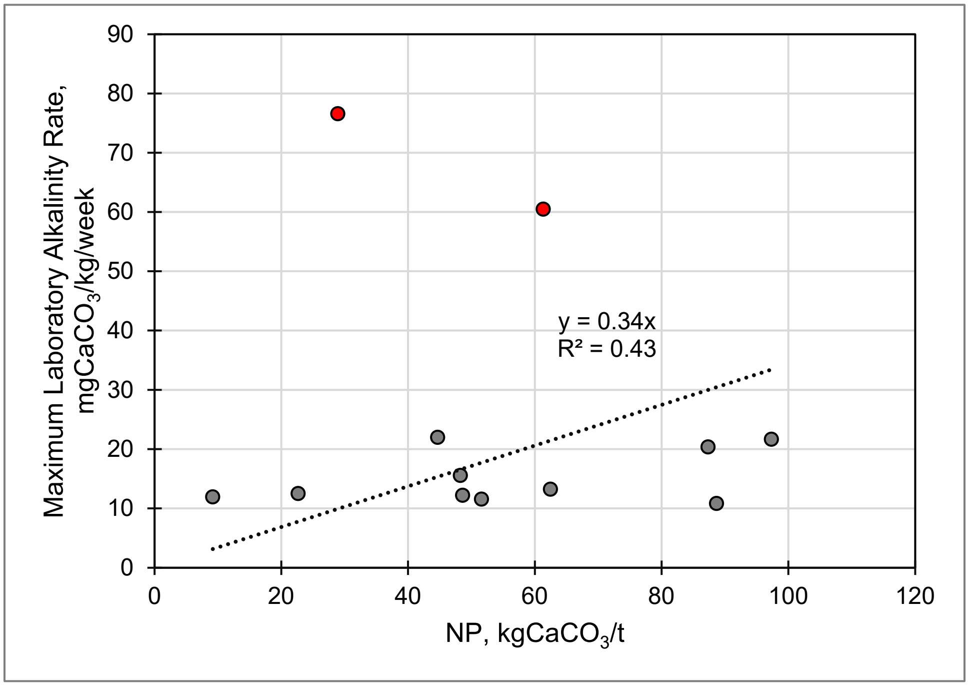


Figure 2. Regression of NP vs. maximum alkalinity rates from laboratory humidity cells.

c. Calculation of ARD onset time

Time to onset of ARD was calculated for all PAG samples from the Marathon deposit using Equation 2 (Table 1). Minimum, median, and maximum values are shown in Table 3 (attached) for the following three groups of samples:

- high grade ore
- low grade ore
- waste rock

The estimates of ARD onset time are conservative because the estimates are based on the laboratory rates. Laboratory derived rates are faster than the respective field rates, which, if field rates were applied, could result in a more realistic estimation of the ARD lag time. This is demonstrated in Table 1 (attached) by comparison of the recent field test results to the laboratory results for the same sample of low-grade ore (MLGO-Met) with an uncertain ARD potential. Field based ARD onset time (200 years) is approximately 30 times longer than the ARD onset time (6.3 years) calculated using laboratory-based inputs for this sample. Nevertheless, the conservative ranges of ARD onset time were used for sensitivity analysis of the water quality model.

Water Quality Model Sensitivity

ARD onset time lags were considered a probabilistic input parameter with triangular probability distributions in both the EIS (original) and sensitivity (models). In the original GoldSim model, one probability distribution was used to represent acidic rates in all mine components (Figure 3). In the sensitivity model for Marathon site, a separate probability distribution of ARD onset was assigned to ore, low grade ore and waste rock in accordance with statistics from Table 3 (attached).

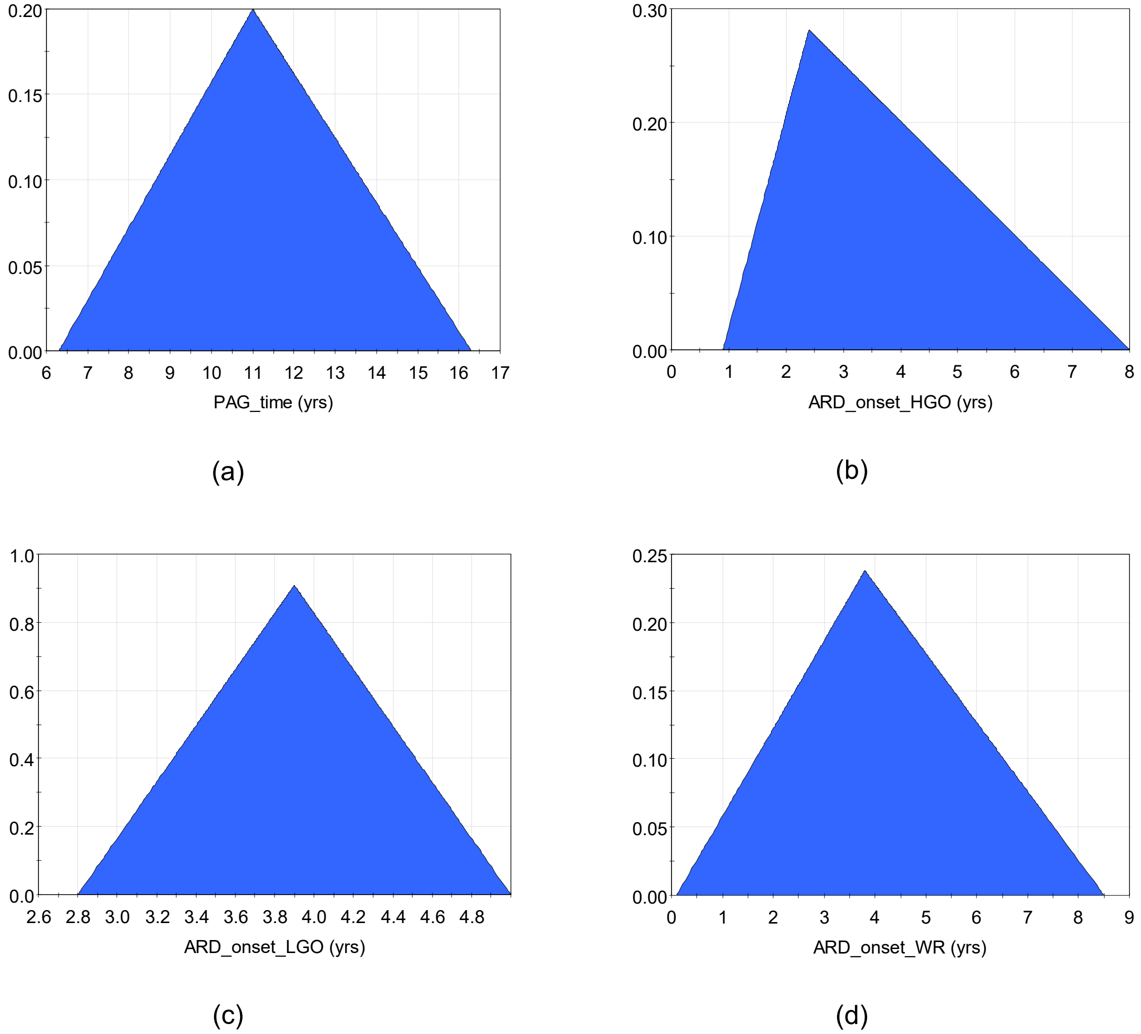


Figure 3. Probability distributions for ARD onset time in the EIS model for all materials (a) and the sensitivity model for ore (b), low grade ore (c), and waste rock (d).

The results obtained for the low-grade ore stockpile, waste rock, and open pit are provided in Tables 4 to 12 (attached). For each of these mine components, three tables are presented: 1) original results from the EIS model; 2) new results from the sensitivity model, and 3) ratios of new results to the original results. Ratios greater than 1.2 are highlighted in gray in the tables indicating a substantial increase from the original result. The key increases can be summarized as follows:

- In the LGO stockpile, increases of up to 3.1x for Zn and 1.5x for Ni concentrations are predicted during operation. Concentrations of these metals remain below MDMER limits at 95% confidence levels.
- In the waste rock stockpile, increases of up to 1.4x for Zn and 1.3x for Ni concentrations are predicted during operation and up to 1.3x for Zn during closure. In both phases of the mine life cycle, concentrations of these metals remain below MDMER limits at 95% confidence levels.
- In mine water from the pit, increases up to 2.4x for Ni, up to 2.2x for Zn, and 1.3x for Cd concentrations are predicted during operation. In the pit lake, an increase in concentration up to 1.21x for Zn is predicted during closure. In both phases of the mine life cycle, concentrations of Ni and Zn are below MDMER limits and Cd concentration remains below the short-term Canadian Water Quality guideline at 95% confidence levels.

Overall model results show that faster ARD onset times result in an increase of average concentrations of Zn, Ni, and Cd generally during operation, and to a lesser degree post-closure. Other parameters were less influenced by ARD onset because there was either a lower or no multiplier used for acidic leaching rates as noted in Section 5.3.1.1 in Appendix 7B of the EIS.

pH of LGO Seepage

The water quality GoldSim model probabilistically assumes that pH in the low-grade ore stockpile will be between 7.5 and 8.5, based on pH measured in the M-LGO humidity cell in the first week (Figure 3). The validity of this assumption can be tested by comparing alkalinity and acidity rates measured in normal (M-LGO) and carbonate depleted (M-LGO CNP DPL) humidity cells, respectively. The alkalinity rate is always greater than the acidity rate over the testing period (Figure 3). On average, the alkalinity production rate (22.5 mg $CaCO_3$/kg/week) is almost 8x higher than the acidity production rate (2.9 mg $CaCO_3$/kg/week) between weeks 10 and 20, when rates stabilized in both cells (Figure 3). This observation indicates that there is more than enough alkalinity produced from 50% of the non-PAG ore to neutralize acidity generated from 50% of the PAG material. Therefore, a reduction of pH below 6.5 in seepage from LGO stockpile is not expected.

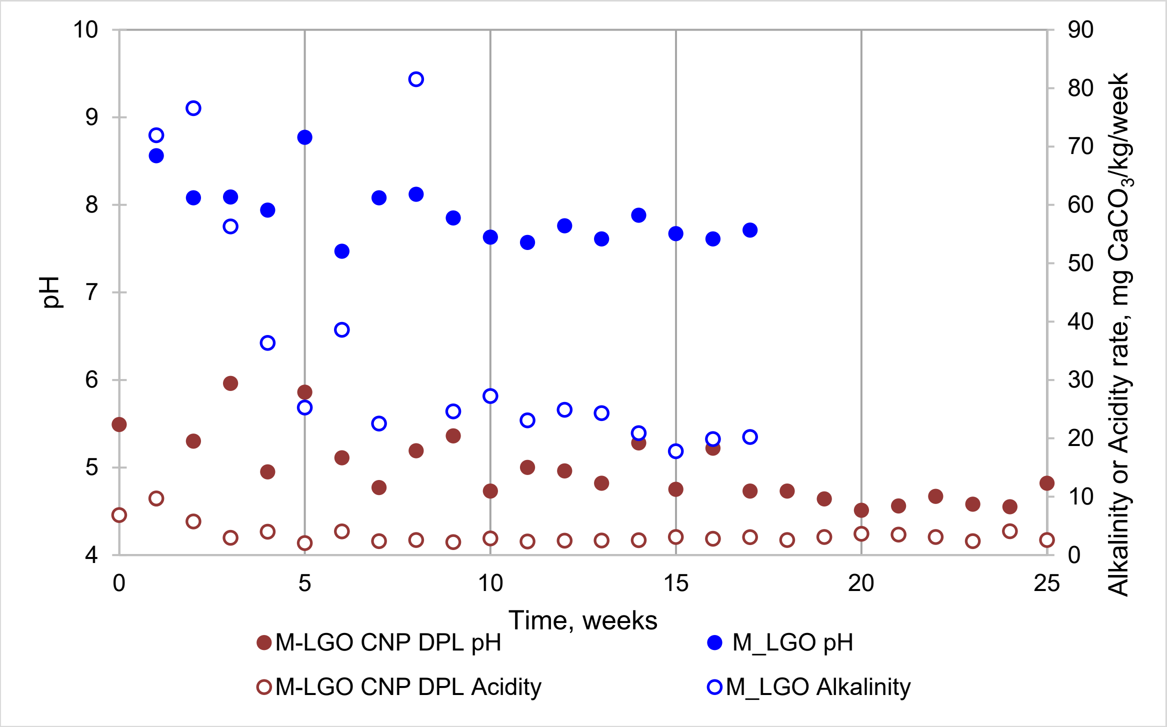


Figure 3. Alkalinity and acidity rates and pH from normal (M-LGO) and carbonate depleted (M-LGO CNP DPL) humidity cells

Summary

Conservative assumptions were used to calculate ARD onset time for PAG samples from the Marathon deposit. These calculations produced conservative (shorter) ARD onset time lags, which were subsequently used to evaluate the sensitivity of the water quality model predictions. Using a stochastic sampling of these inputs, the model predictions did not exceed the MDMER limits in discharges from the LGO stockpile, waste rock, or open pit over the life of the proposed mine. Therefore, treatment of these discharges is not required, which is the same conclusion presented in the EIS.

References:

Mine Environment Neutral Drainage Program (MEND), 2009. Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials, MEND Report 1.20.1, p. 1-579.

SRK Consulting. 2006. Galore Creek Project ML/ARD Characterization Report. Report prepared for Novagold Resources Inc. SRK Project. 1CR003.002. May 2006.

SRK 2013. Metal Leaching and Acid Rock Drainage Potential Characterization Sisson Project. August 2013.

TABLES 1 TO 12

Table 1: Estimates of rates and NP depletion time in kinetic tets

Parameter	Unit	Leprechaun composite samples						Marathon composite samples						
		Laboratory Humididty cells						Laboratory Humididty cells						Field bin
		L TRJ	L QZ-TQTP	L SED	L MD	L QZ-QTP	LLGO - Met	M QE-POR	M AQPOR	M CG	M MD	M QZ-QE-POR-QTP-MIN	MLGO - Met	MLGO - Met
S_{TOTAL}	wt.%	0.080	0.11	0.003	0.13	0.048	0.27	0.083	0.33	0.003	0.27	0.38	0.59	0.59
Carb. NP	kg $CaCO_3$/t	48.3	44.7	9.2	97.3	51.6	61.3	62.5	48.6	87.3	88.7	22.7	28.9	28.9
AP	kg $CaCO_3$/t	0.94	1.88	0.62	2.19	0.62	7.19	1.56	7.50	0.62	5.94	8.75	18.8	18.8
Carb. NPR	unitless	51	24	15	44	83	8.5	40	6.5	141	15	2.6	1.5	1.5
Max Sulphate Rate	mg/kg/week	1.17	2.9	0.70	1.38	1.06	8.3	1.8	4.6	0.51	46.7	1.15	10.5	0.45
Max Alkalinity Rate	mg $CaCO_3$/kg/week	16	22	11.9	22	12	60	13	12	20	11	12	77	2.3
NP Depletion Rate	mg $CaCO_3$/kg/week	17	25	13	23	13	69	15	17	21	59	14	88	3
NP Depletion Time	year	55	34	14	81	78	17	79	55	80	29	32	6.3	200
AP Depletion Time	year	15	12	16	29	11	16	16	30	22	2.3	140	33	768

Notes:

NP Depetion Rate = Max Sulphate Rate*100.09/96.06 + Max Alkalinity Rate

NP Depletion Time = (Carb. NP/Max NP Depetion Rate) x 1000/(365.25/7)

Table 2: Inputs and results of ARD onset time calculation for PAG samples from Marathon deposit.

Sample ID	Lithocode and material	Au	Total S	Carb. NP	AP from total S	Carb NPR	Sulfate rate	Alkalinity rate	NP depletion rate	ARD onset time
Units	Lithocode and material	ppb	wt.%	kg $CaCO_3$/t		unitless	mg/kg/week			years
MA-16-116	1. QE-POR	102	0.30	6.1	8.8	0.7	4.7	67.7	72.6	1.6
MA-16-079	1. QE-POR	9	0.35	14.6	10.9	1.3	5.5	67.7	73.4	3.8
MA-15-035	1. QE-POR	5	0.59	28.0	18.4	1.5	9.2	67.7	77.3	6.9
MA-18-281 177251	1. QE-POR	14	0.580	23.2	14.4	1.6	9.0	67.7	77.1	5.8
MA-18-278 167699	1. QE-POR	5	0.811	33.8	19.1	1.8	12.7	67.7	80.9	8.0
MA-18-290 178278	2. AQPOR	28	2.52	0.4	67.2	0.0	39.3	67.7	108.7	0.1
MA-18-281 177047	2. AQPOR	23	1.08	18.5	26.6	0.7	16.8	67.7	85.3	4.2
MA-16-156 108817	2. AQPOR	14	0.202	5.1	3.75	1.4	3.2	67.7	71.0	1.4
MA-16-082	4. GB	5	3.04	12.3	94.7	0.1	47.4	67.7	117.1	2.0
MA-18-280 167924	6. QZ-QE-POR-QTP-MIN	88	0.808	12.5	21.2	0.6	12.6	67.7	80.8	3.0
MA-18-290 178314	6. QZ-QE-POR-QTP-MIN	5	0.654	15.3	17.2	0.9	10.2	67.7	78.3	3.7
MA-16-101	7. QZ-QE-POR-QTP	238	0.54	14.3	16.9	0.8	8.4	67.7	76.5	3.6
MA-16-116	7. QZ-QE-POR-QTP	15	1.04	37.7	32.2	1.2	16.2	67.7	84.6	8.5
MA-14-015	7. QZ-QE-POR-QTP	171	0.35	16.8	10.6	1.6	5.5	67.7	73.4	4.4
MA-18-267 175269	7. QZ-QE-POR-QTP	276	0.266	10.4	6.25	1.7	4.1	67.7	72.0	2.8
MA-16-156 108949	7. QZ-QE-POR-QTP	24	0.370	18.3	9.38	2.0	5.8	67.7	73.7	4.8
MA-16-101	Low Grade Ore	539	1.18	14.1	36.9	0.4	18.4	67.7	86.9	3.1
MA-18-287 177901	Low Grade Ore	637	0.655	11.4	18.1	0.6	10.2	67.7	78.3	2.8
MA-18-267 175199	Low Grade Ore	387	0.492	18.5	11.6	1.6	7.7	67.7	75.7	4.7
MA-16-122	Low Grade Ore	352	0.32	18.9	9.7	1.9	5.0	67.7	72.9	5.0
MA-16-156 108866	Ore	1115	1.16	4.1	29.1	0.1	18.1	67.7	86.6	0.9
MA-16-116	Ore	3272	0.80	5.9	25.0	0.2	12.5	67.7	80.7	1.4
MA-18-280 167946	Ore	2517	0.674	7.9	17.8	0.4	10.5	67.7	78.7	1.9
MA-16-101	Ore	4465	0.71	10.0	22.2	0.5	11.1	67.7	79.2	2.4
MA-18-290 178287	Ore	1531	0.790	12.3	20.9	0.6	12.3	67.7	80.5	2.9
MA-17-216 145319	Ore	2177	0.944	30.7	25.6	1.2	14.7	67.7	83.0	7.1
MA-16-116	Ore	14388	0.51	31.6	15.6	2.0	8.0	67.7	76.0	8.0

Table 3: Ranges of ARD onset time for selected PAG materials from Marathon deposit.

Material	Statistic	Au	Total S	Carb. NP	AP from total S	Carb NPR	Sulfate rate	Alkalinity rate	NP depletion rate	ARD onset time
Units		ppb	wt.%	kg $CaCO_3$/t		unitless	mg/kg/week			years
Ore (High Grade Ore)	Min	5	0.20	0.4	3.8	0.01	3.2	67.7	71.0	0.9
	Median	171	0.66	14.3	18.1	0.9	10.2	67.7	78.3	2.4
	Max	14388	3.04	37.7	94.7	2.0	47.4	67.7	117.1	8.0
Low Grade Ore (LGO)	Min	352	0.32	11.4	9.7	0.4	5.0	67.7	72.9	2.8
	Median	463	0.57	16.3	14.9	1.1	8.9	67.7	77.0	3.9
	Max	637	1.18	18.9	36.9	1.9	18.4	67.7	86.9	5.0
Waste Rock	Min	5	0.20	0.4	3.8	0.0	3.2	67.7	71.0	0.1
	Median	19	0.59	14.9	17.1	1.3	9.1	67.7	77.2	3.8
	Max	276	3.04	37.7	94.7	2.0	47.4	67.7	117.1	8.5

Table 4: The highest value of the monthly mean and 95th %-ile for each project phase in seepage from the low grade ore stockpile in the EIS model.

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	16	22	86	100	**600**	**600**
Antimony	µg/L	-	-	-	0.5	0.5	0.97	1.10	20	25
Arsenic	µg/L	100	-	5	0.5	0.5	0.8	0.9	**13**	**15**
Barium	µg/L	-	-	-	2.3	3	3.7	4.1	62	73
Boron	µg/L	-	29000	1500	25	25	30	31	220	270
Cadmium	µg/L	-	0.13	0.04	0.01	0.01	0.009	0.011	**0.18**	**0.21**
Calcium	µg/L	-	-	-	2800	2900	6300	7200	150000	180000
Chromium	µg/L	-	-	1	1.1	1.9	**1.2**	**1.8**	**3.3**	**4.0**
Copper	µg/L	100	-	2	0.6	0.9	0.86	0.97	**13**	**15**
Iron	µg/L	-	-	300	25	25	28	29	180	270
Lead	µg/L	80	-	1	0.25	0.25	0.27	0.27	0.92	**1.10**
Magnesium	µg/L	-	-	-	340	350	720	800	16000	19000
Manganese	µg/L	-	596	210	5.5	6.8	19	23	**610**	**740**
Mercury	µg/L	-	-	0.026	0.007	0.007	0.010	0.010	**0.15**	**0.19**
Molybdenum	µg/L	-	-	73	1.0	1.0	3.7	4.5	**110**	**140**
Nickel	µg/L	250	-	25	1.0	1.0	1.2	1.2	7.9	10
Phosphorus	µg/L	-	-	4	50	50	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	95	130	570	700	20000	24000
Selenium	µg/L	-	-	1	0.25	0.25	0.39	0.44	**6.1**	**7.4**
Silver	µg/L	-	-	0.25	0.05	0.05	0.066	0.070	**0.69**	**0.83**
Sodium	µg/L	-	-	-	1400	1500	3600	4300	91000	110000
Thallium	µg/L	-	-	0.8	0.05	0.05	0.056	0.059	0.31	0.40
Uranium	µg/L	-	33	15	0.05	0.05	0.86	1.20	**31**	**42**
Zinc	µg/L	400	11.3	2.2	2.5	2.5	**3.1**	**3.3**	**88**	**250**
Chloride	µg/L	-	640000	120000	2400	2600	2400	2600	2400	2600
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	38	53	4800	12000	12000	15000
Nitrite (as Nitrogen)	µg/L	-	-	60	9.9	14	**120**	**280**	**270**	**350**
Nitrate (as Nitrogen)	µg/L	-	550000	13000	25	25	4600	12000	11000	**15000**
Total Ammonia (as Nitrogen)	µg/L	-	-	689	25	25	610	**1500**	**1500**	**1900**
Un-ionized Ammonia (as Nitrogen)	µg/L	500	-	19	0.064	0.097	**23.0**	**57**	**57**	**72**
Cyanide, Total	µg/L	500	-	-	10	10	10	10	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	1000	1000	5400	6800	180000	220000
Fluoride	µg/L	-	-	120	60	60	85	93	**1100**	**1300**
Radium-226	Bq/L	0.37	-	-	0.005	0.005	0.0067	0.0071	0.074	0.088
Temperature	°C	-	-	-	12.0	17.0	9	17	9	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	8.8	9.7	12000	15000	510000	610000
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.0	6.9	8.0	8.0	8.0	8.0
Hardness (as $CaCO_3$)	mg/L	-	-	-	8.4	8.7	19	21	440	530
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.3	1.4	15	18

Notes:

MDMER - Metal and Diamond Mining Effluent Regulations (Canada), Table 1 of Schedule 4, Maximum Authorized Monthly Mean Concentrations (SOR/2002-222 2020).

CWQG - Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life, short-term and long-term (CWQG-FAL referred to as CWQG) by Canadian Council of Ministers of the Environment (CCME 2020).

Concentrations exceeding MDMER are highlighted gray, CWQG short-term are double underlined, and CWQG long-term are bold.

For further details on the parameters and guidelines see Table C-1 notes in Appendix 7B of the EIS.

Table 5: The highest value of the monthly mean and 95th %-ile for each project phase in seepage from the low grade ore stockpile in the sensitivity model.

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	16	22	86	100	**600**	**600**
Antimony	µg/L	-	-	-	0.5	0.5	0.97	1.10	20	25
Arsenic	µg/L	100	-	5	0.5	0.5	0.8	0.9	**13**	**15**
Barium	µg/L	-	-	-	2.3	3	3.7	4.1	62	73
Boron	µg/L	-	29000	1500	25	25	30	31	220	270
Cadmium	µg/L	-	0.13	0.04	0.01	0.01	0.009	0.011	**0.18**	**0.21**
Calcium	µg/L	-	-	-	2800	2900	6300	7200	150000	180000
Chromium	µg/L	-	-	1	1.1	1.9	**1.2**	**1.8**	**3.3**	**4.0**
Copper	µg/L	100	-	2	0.6	0.9	0.86	0.97	**13**	**15**
Iron	µg/L	-	-	300	25	25	28	29	270	**310**
Lead	µg/L	80	-	1	0.25	0.25	0.27	0.27	0.92	**1.10**
Magnesium	µg/L	-	-	-	340	350	720	800	16000	19000
Manganese	µg/L	-	596	210	5.5	6.8	19	23	**610**	**740**
Mercury	µg/L	-	-	0.026	0.007	0.007	0.010	0.010	**0.17**	**0.20**
Molybdenum	µg/L	-	-	73	1.0	1.0	3.7	4.5	**110**	**140**
Nickel	µg/L	250	-	25	1.0	1.0	1.2	1.2	9.4	11
Phosphorus	µg/L	-	-	4	50	50	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	95	130	570	700	20000	24000
Selenium	µg/L	-	-	1	0.25	0.25	0.39	0.44	**6.1**	**7.4**
Silver	µg/L	-	-	0.25	0.05	0.05	0.066	0.070	**0.69**	**0.83**
Sodium	µg/L	-	-	-	1400	1500	3600	4300	91000	110000
Thallium	µg/L	-	-	0.8	0.05	0.05	0.056	0.059	0.31	0.40
Uranium	µg/L	-	33	15	0.05	0.05	0.86	1.20	**31**	**42**
Zinc	µg/L	400	11.3	2.2	2.5	2.5	**3.1**	**3.3**	**270**	**310**
Chloride	µg/L	-	640000	120000	2400	2600	2400	2600	2400	2600
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	38	53	4800	12000	12000	15000
Nitrite (as Nitrogen)	µg/L	-	-	60	9.9	14	**120**	**280**	**270**	**350**
Nitrate (as Nitrogen)	µg/L	-	550000	13000	25	25	4600	12000	11000	**15000**
Total Ammonia (as Nitrogen)	µg/L	-	-	689	25	25	610	**1500**	**1500**	**1900**
Un-ionized Ammonia (as Nitrogen)	µg/L	500	-	19	0.064	0.097	**23.0**	**57**	**57**	**72**
Cyanide, Total	µg/L	500	-	-	10	10	10	10	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	1000	1000	5400	6800	180000	220000
Fluoride	µg/L	-	-	120	60	60	85	93	**1100**	**1300**
Radium-226	Bq/L	0.37	-	-	0.005	0.005	0.0067	0.0071	0.074	0.088
Temperature	°C	-	-	-	12.0	17.0	9	17	9	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	8.8	9.7	12000	15000	510000	610000
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.0	6.9	8.0	8.0	8.0	8.0
Hardness (as $CaCO_3$)	mg/L	-	-	-	8.4	8.7	19	21	440	530
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.3	1.4	15	18

Notes:

MDMER - Metal and Diamond Mining Effluent Regulations (Canada), Table 1 of Schedule 4, Maximum Authorized Monthly Mean Concentrations (SOR/2002-222 2020).

CWQG - Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life, short-term and long-term (CWQG-FAL referred to as CWQG) by Canadian Council of Ministers of the Environment (CCME 2020).

Concentrations exceeding MDMER are highlighted gray, CWQG short-term are double underlined, and CWQG long-term are bold.

For further details on the parameters and guidelines see Table C-1 notes in Appendix 7B of the EIS.

Table 6: Concentration ratios between the sensitivity and EIS models for LGO.

Parameter	Baseline		Construction		Operation	
Statistics	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	1.0	1.0	1.0	1.0	1.0	1.0
Antimony	1.0	1.0	1.0	1.0	1.0	1.0
Arsenic	1.0	1.0	1.0	1.0	1.0	1.0
Barium	1.0	1.0	1.0	1.0	1.0	1.0
Boron	1.0	1.0	1.0	1.0	1.0	1.0
Cadmium	1.0	1.0	1.0	1.0	1.0	1.0
Calcium	1.0	1.0	1.0	1.0	1.0	1.0
Chromium	1.0	1.0	1.0	1.0	1.0	1.0
Copper	1.0	1.0	1.0	1.0	1.0	1.0
Iron	1.0	1.0	1.0	1.0	**1.5**	1.1
Lead	1.0	1.0	1.0	1.0	1.0	1.0
Magnesium	1.0	1.0	1.0	1.0	1.0	1.0
Manganese	1.0	1.0	1.0	1.0	1.0	1.0
Mercury	1.0	1.0	1.0	1.0	1.1	1.1
Molybdenum	1.0	1.0	1.0	1.0	1.0	1.0
Nickel	1.0	1.0	1.0	1.0	1.2	1.1
Phosphorus	1.0	1.0	1.0	1.0	1.0	1.0
Potassium	1.0	1.0	1.0	1.0	1.0	1.0
Selenium	1.0	1.0	1.0	1.0	1.0	1.0
Silver	1.0	1.0	1.0	1.0	1.0	1.0
Sodium	1.0	1.0	1.0	1.0	1.0	1.0
Thallium	1.0	1.0	1.0	1.0	1.0	1.0
Uranium	1.0	1.0	1.0	1.0	1.0	1.0
Zinc	1.0	1.0	1.0	1.0	**3.1**	**1.2**
Chloride	1.0	1.0	1.0	1.0	1.0	1.0
Nitrate + Nitrite (as Nitrogen)	1.0	1.0	1.0	1.0	1.0	1.0
Nitrite (as Nitrogen)	1.0	1.0	1.0	1.0	1.0	1.0
Nitrate (as Nitrogen)	1.0	1.0	1.0	1.0	1.0	1.0
Total Ammonia (as Nitrogen)	1.0	1.0	1.0	1.0	1.0	1.0
Un-ionized Ammonia (as Nitrogen)	1.0	1.0	1.0	1.0	1.0	1.0
Cyanide, Total	1.0	1.0	1.0	1.0	1.0	1.0
Cyanide, WAD	1.0	1.0	1.0	1.0	1.0	1.0
Sulphate	1.0	1.0	1.0	1.0	1.0	1.0
Fluoride	1.0	1.0	1.0	1.0	1.0	1.0
Radium-226	1.0	1.0	1.0	1.0	1.0	1.0
Temperature	1.0	1.0	1.0	1.0	1.0	1.0
Total Alkalinity (as $CaCO_3$)	1.0	1.0	1.0	1.0	1.0	1.0
pH (mean or 5 %ile)	1.0	1.0	1.0	1.0	1.0	1.0
Hardness (as $CaCO_3$)	1.0	1.0	1.0	1.0	1.0	1.0
Dissolved Organic Carbon	1.0	1.0	1.0	1.0	1.0	1.0

Note: Ratios above 1.2 are bold and highlighted gray.

Table 7: The highest value of the monthly mean and 95th %-ile for each project phase in seepage from the waste rock stockpile in the EIS model.

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	16	22	20	21	**600**	**600**	**600**	**600**	**600**	**600**
Antimony	µg/L	-	-	-	0.5	0.5	0.52	0.53	34	39	30	35	17	20
Arsenic	µg/L	100	-	5	0.5	0.5	0.5	0.5	**24**	**28**	**10.0**	**12**	**5.6**	**6.6**
Barium	µg/L	-	-	-	2.3	3	2.4	2.9	120	140	80	93	46	54
Boron	µg/L	-	29000	1500	25	25	25	25	130	150	93	100	63	70
Cadmium	µg/L	-	0.13	0.04	0.01	0.01	0.01	0.01	**0.23**	**0.27**	**0.22**	**0.26**	**0.14**	**0.17**
Calcium	µg/L	-	-	-	2800	2900	3000	3100	290000	340000	200000	240000	110000	140000
Chromium	µg/L	-	-	1	1.1	1.9	1.2	1.8	**7.8**	**9.2**	**7.4**	**9**	**4.8**	**5.5**
Copper	µg/L	100	-	2	0.6	0.9	0.7	0.9	**74**	**88**	**54**	**60**	**32**	**38**
Iron	µg/L	-	-	300	25	25	25	25	**570**	**680**	**350**	**420**	230	270
Lead	µg/L	80	-	1	0.25	0.25	0.25	0.25	**2.2**	**2.8**	**2.10**	**2.7**	**1.40**	**1.80**
Magnesium	µg/L	-	-	-	340	350	350	360	28000	33000	21000	24000	12000	14000
Manganese	µg/L	-	596	210	5.5	6.8	6.3	6.9	**1300**	**1300**	**980**	**1100**	**580**	**690**
Mercury	µg/L	-	-	0.026	0.007	0.007	0.007	0.007	**0.52**	**0.61**	**0.48**	**0.55**	**0.30**	**0.36**
Molybdenum	µg/L	-	-	73	1.0	1.0	1.0	1.0	38	44	28	34	17.0	20.0
Nickel	µg/L	250	-	25	1.0	1.0	1.0	1.0	6.8	8.8	6.7	8.5	5.0	5.9
Phosphorus	µg/L	-	-	4	50	50	50	50	**50**	**50**	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	95	130	130	140	56000	67000	14000	17000	6600	7800
Selenium	µg/L	-	-	1	0.25	0.25	0.25	0.25	**3.5**	**4.1**	**1.8**	**2.0**	**1.1**	**1.2**
Silver	µg/L	-	-	0.25	0.05	0.05	0.051	0.052	**1.9**	**2.2**	**1.7**	**1.9**	**1.0**	**1.2**
Sodium	µg/L	-	-	-	1400	1500	1500	1500	130000	160000	19000	24000	7400	9200
Thallium	µg/L	-	-	0.8	0.05	0.05	0.05	0.05	0.28	0.32	0.26	0.30	0.17	0.20
Uranium	µg/L	-	33	15	0.05	0.05	0.081	0.089	**42**	**52**	14	**17**	8	9
Zinc	µg/L	400	11.3	2.2	2.5	2.5	2.5	2.6	**140**	**200**	**140**	**200**	**110**	**130**
Chloride	µg/L	-	640000	120000	2400	2600	2400	2600	2400	2600	2400	2600	2400	2600
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	38	53	5900	15000	23000	30000	470	910	83	160
Nitrite (as Nitrogen)	µg/L	-	-	60	9.9	14	140	340	**530**	**670**	19	29	11.0	14
Nitrate (as Nitrogen)	µg/L	-	550000	13000	25	25	5800	15000	**23000**	**29000**	450	880	71	150
Total Ammonia (as Nitrogen)	µg/L	-	-	689	25	25	750	1900	**2900**	**3700**	80	130	32	41
Un-ionized Ammonia (as Nitrogen)	µg/L	500	-	19	0.064	0.097	29	72	**110**	**140**	3.0	4.9	1.2	1.6
Cyanide, Total	µg/L	500	-	-	10	10	10	10	10	10	10	10	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	1000	1000	1100	1200	210000	260000	160000	190000	96000	120000
Fluoride	µg/L	-	-	120	60	60	61	62	**1600**	**1600**	**1600**	**1600**	**1600**	**1600**
Radium-226	Bq/L	0.37	-	-	0.005	0.005	0.0051	0.0052	0.20	0.23	0.18	0.21	0.10	0.12
Temperature	°C	-	-	-	12.0	17.0	11.0	17.0	12.0	17	11.0	17	12	17
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	8.8	9.7	660	820	900000	1100000	540000	620000	300000	350000
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.0	6.9	7.9	7.7	8.0	7.7	7.3	7.2	7.3	7.2
Hardness (as $CaCO_3$)	mg/L	-	-	-	8.4	8.7	8.9	9.2	840	980	590	700	320	410
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.0	40	47	36	42	21	25

Notes:

MDMER - Metal and Diamond Mining Effluent Regulations (Canada), Table 1 of Schedule 4, Maximum Authorized Monthly Mean Concentrations (SOR/2002-222 2020).

CWQG - Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life, short-term and long-term (CWQG-FAL referred to as CWQG) by Canadian Council of Ministers of the Environment (CCME 2020).

Concentrations exceeding MDMER are highlighted gray, CWQG short-term are double underlined, and CWQG long-term are bold.

For further details on the parameters and guidelines see Table C-1 notes in Appendix 7B of the EIS.

Table 8: The highest value of the monthly mean and 95th %-ile for each project phase in seepage from the waste rock stockpile in the sensitivity model.

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	16	22	20	21	**600**	**600**	**600**	**600**	**600**	**600**
Antimony	µg/L	-	-	-	0.5	0.5	0.52	0.53	36	41	33	37	20	24
Arsenic	µg/L	100	-	5	0.5	0.5	0.5	0.5	**22**	**26**	**11.0**	**12**	**6.2**	**7.2**
Barium	µg/L	-	-	-	2.3	3	2.4	2.9	120	140	91	110	55	65
Boron	µg/L	-	29000	1500	25	25	25	25	130	150	99	110	68	76
Cadmium	µg/L	-	0.13	0.04	0.01	0.01	0.01	0.01	**0.24**	**0.28**	**0.23**	**0.26**	**0.14**	**0.17**
Calcium	µg/L	-	-	-	2800	2900	3000	3100	300000	350000	230000	260000	140000	160000
Chromium	µg/L	-	-	1	1.1	1.9	1.2	1.8	**8.3**	**9.6**	**8.0**	**9**	**5.3**	**6.2**
Copper	µg/L	100	-	2	0.6	0.9	0.7	0.9	**72**	**85**	**54**	**60**	**32**	**38**
Iron	µg/L	-	-	300	25	25	25	25	**610**	**720**	**380**	**430**	230	270
Lead	µg/L	80	-	1	0.25	0.25	0.25	0.25	**2.3**	**3.0**	**2.20**	**2.7**	**1.40**	**1.80**
Magnesium	µg/L	-	-	-	340	350	350	360	28000	33000	23000	26000	14000	16000
Manganese	µg/L	-	596	210	5.5	6.8	6.3	6.9	**1300**	**1300**	**980**	**1100**	**580**	**690**
Mercury	µg/L	-	-	0.026	0.007	0.007	0.007	0.007	**0.53**	**0.62**	**0.49**	**0.57**	**0.30**	**0.36**
Molybdenum	µg/L	-	-	73	1.0	1.0	1.0	1.0	38	44	31	38	19.0	23.0
Nickel	µg/L	250	-	25	1.0	1.0	1.0	1.0	8.6	9.8	7.8	8.7	5.1	5.9
Phosphorus	µg/L	-	-	4	50	50	50	50	**50**	**50**	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	95	130	130	140	52000	61000	15000	17000	7500	8800
Selenium	µg/L	-	-	1	0.25	0.25	0.25	0.25	**3.3**	**3.9**	**1.9**	**2.2**	**1.2**	**1.4**
Silver	µg/L	-	-	0.25	0.05	0.05	0.051	0.052	**2.0**	**2.3**	**1.8**	**2.1**	**1.1**	**1.3**
Sodium	µg/L	-	-	-	1400	1500	1500	1500	120000	140000	19000	24000	8400	10000
Thallium	µg/L	-	-	0.8	0.05	0.05	0.05	0.05	0.30	0.33	0.28	0.32	0.19	0.22
Uranium	µg/L	-	33	15	0.05	0.05	0.081	0.089	**39**	**48**	15	**18**	8	10
Zinc	µg/L	400	11.3	2.2	2.5	2.5	2.5	2.6	**200**	**230**	**180**	**210**	**110**	**130**
Chloride	µg/L	-	640000	120000	2400	2600	2400	2600	2400	2600	2400	2600	2400	2600
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	38	53	5900	15000	23000	30000	470	910	83	160
Nitrite (as Nitrogen)	µg/L	-	-	60	9.9	14	140	340	**530**	**670**	19	29	11.0	14
Nitrate (as Nitrogen)	µg/L	-	550000	13000	25	25	5800	15000	**23000**	**29000**	450	880	71	150
Total Ammonia (as Nitrogen)	µg/L	-	-	689	25	25	750	1900	**2900**	**3700**	80	130	32	42
Un-ionized Ammonia (as Nitrogen)	µg/L	500	-	19	0.064	0.097	29	72	**110**	**140**	3.0	4.9	1.2	1.6
Cyanide, Total	µg/L	500	-	-	10	10	10	10	10	11	10	10	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	1000	1000	1100	1200	220000	260000	160000	190000	97000	120000
Fluoride	µg/L	-	-	120	60	60	61	62	**1600**	**1600**	**1600**	**1600**	**1600**	**1600**
Radium-226	Bq/L	0.37	-	-	0.005	0.005	0.0051	0.0052	0.21	0.24	0.20	0.22	0.12	0.14
Temperature	°C	-	-	-	12.0	17.0	11.0	17.0	12.0	17	11.0	17	12	17
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	8.8	9.7	660	820	870000	1000000	590000	670000	340000	410000
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.0	6.9	7.9	8.1	8.0	8.2	7.3	7.5	7.3	7.5
Hardness (as $CaCO_3$)	mg/L	-	-	-	8.4	8.7	8.9	9.2	860	1000	670	760	410	470
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.0	43	49	39	44	24	28

Notes:

MDMER - Metal and Diamond Mining Effluent Regulations (Canada), Table 1 of Schedule 4, Maximum Authorized Monthly Mean Concentrations (SOR/2002-222 2020).

CWQG - Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life, short-term and long-term (CWQG-FAL referred to as CWQG) by Canadian Council of Ministers of the Environment (CCME 2020).

Concentrations exceeding MDMER are highlighted gray, CWQG short-term are double underlined, and CWQG long-term are bold.

For further details on the parameters and guidelines see Table C-1 notes in Appendix 7B of the EIS.

Table 9: Concentration ratios between the sensitivity and EIS models for waste rock.

Parameter	Construction		Operation		Closure		Post-closure	
Statistics	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Antimony	1.0	1.0	1.1	1.1	1.1	1.1	1.0	1.0
Arsenic	1.0	1.0	0.9	0.9	1.1	1.0	1.0	1.0
Barium	1.0	1.0	1.0	1.0	1.1	1.2	1.0	1.0
Boron	1.0	1.0	1.0	1.0	1.1	1.1	1.0	1.0
Cadmium	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Calcium	1.0	1.0	1.0	1.0	1.2	1.1	1.0	1.0
Chromium	1.0	1.0	1.1	1.0	1.1	1.1	1.0	1.0
Copper	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Iron	1.0	1.0	1.1	1.1	1.1	1.0	1.0	1.0
Lead	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.0
Magnesium	1.0	1.0	1.0	1.0	1.1	1.1	1.0	1.0
Manganese	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mercury	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Molybdenum	1.0	1.0	1.0	1.0	1.1	1.1	1.0	1.0
Nickel	1.0	1.0	**1.3**	1.1	1.2	1.0	1.0	1.0
Phosphorus	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Potassium	1.0	1.0	0.9	0.9	1.1	1.0	1.0	1.0
Selenium	1.0	1.0	0.9	1.0	1.1	1.1	1.0	1.0
Silver	1.0	1.0	1.1	1.0	1.1	1.1	1.0	1.0
Sodium	1.0	1.0	0.9	0.9	1.0	1.0	1.0	1.0
Thallium	1.0	1.0	1.1	1.0	1.1	1.1	1.0	1.0
Uranium	1.0	1.0	0.9	0.9	1.1	1.1	1.0	1.0
Zinc	1.0	1.0	**1.4**	1.2	**1.3**	1.1	1.0	1.0
Chloride	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Nitrate + Nitrite (as Nitrogen)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Nitrite (as Nitrogen)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Nitrate (as Nitrogen)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total Ammonia (as Nitrogen)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Un-ionized Ammonia (as Nitrogen)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cyanide, Total	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.0
Cyanide, WAD	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.0
Sulphate	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Fluoride	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Radium-226	1.0	1.0	1.1	1.0	1.1	1.0	1.0	1.0
Temperature	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total Alkalinity (as $CaCO_3$)	1.0	1.0	1.0	0.9	1.1	1.1	1.0	1.0
pH (mean or 5 %ile)	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.0
Hardness (as $CaCO_3$)	1.0	1.0	1.0	1.0	1.1	1.1	1.0	1.0
Dissolved Organic Carbon	1.0	1.0	1.1	1.0	1.1	1.0	1.0	1.0

Note: Ratios above 1.2 are bold and highlighted gray.

Table 10: The highest value of the monthly mean and 95th %-ile for each project phase in pit water in the EIS model.

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	16	22	20	29	**210**	**300**	100	**110**	**120**	**120**
Antimony	µg/L	-	-	-	0.5	0.5	0.50	0.50	3.8	4.7	1.0	1.1	0.71	0.77
Arsenic	µg/L	100	-	5	0.5	0.5	1.4	2.1	3.2	3.7	2.2	2.4	2.2	2.3
Barium	µg/L	-	-	-	2.3	3	5.2	7.6	17	22	4	5	4	5
Boron	µg/L	-	29000	1500	25	25	25	25	32	38	25	25	25	25
Cadmium	µg/L	-	0.13	0.04	0.01	0.01	0.010	0.015	0.025	0.030	0.017	0.019	0.015	0.016
Calcium	µg/L	-	-	-	2800	2900	68000	98000	75000	96000	14000	15000	22000	22000
Chromium	µg/L	-	-	1	1.1	1.9	**1.1**	**1.8**	**1.5**	**2.4**	**1.4**	**1.9**	**1.3**	**1.9**
Copper	µg/L	100	-	2	0.6	0.9	1	1.3	**6.5**	**7.8**	1.7	1.8	1.3	1.4
Iron	µg/L	-	-	300	25	25	**480**	**880**	**440**	**800**	210	230	**320**	**330**
Lead	µg/L	80	-	1	0.25	0.25	0.25	0.25	0.27	0.31	0.25	0.25	0.25	0.25
Magnesium	µg/L	-	-	-	340	350	6500	9800	6900	9500	1500	1700	2200	2300
Manganese	µg/L	-	596	210	5.5	6.8	**620**	**1100**	**510**	**840**	160	170	190	200
Mercury	µg/L	-	-	0.026	0.007	0.007	0.007	0.007	**0.04**	**0.05**	0.014	0.015	0.011	0.012
Molybdenum	µg/L	-	-	73	1.0	1.0	5.6	8.0	13	16	3	3	3	3
Nickel	µg/L	250	-	25	1.0	1.0	1.0	1.0	1.3	1.7	1.0	1.1	1.0	1.0
Phosphorus	µg/L	-	-	4	50	50	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	95	130	600	860	5500	6700	600	690	400	430
Selenium	µg/L	-	-	1	0.25	0.25	0.38	0.39	0.8	1.0	0.46	0.48	0.41	0.42
Silver	µg/L	-	-	0.25	0.05	0.05	0.050	0.050	0.19	0.23	0.069	0.075	0.058	0.060
Sodium	µg/L	-	-	-	1400	1500	42000	70000	40000	64000	6300	7000	12000	12000
Thallium	µg/L	-	-	0.8	0.05	0.05	0.050	0.050	0.054	0.062	0.050	0.050	0.050	0.050
Uranium	µg/L	-	33	15	0.05	0.05	0.78	0.92	5.3	6.6	0.6	0.7	0.41	0.43
Zinc	µg/L	400	11.3	2.2	2.5	2.5	**2.5**	**2.5**	**13**	**32**	**6.8**	**9.0**	**6.1**	**7.0**
Chloride	µg/L	-	640000	120000	2400	2600	36000	59000	33000	48000	5300	5900	9200	9400
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	38	53	720	1800	4900	9400	100	120	83	91
Nitrite (as Nitrogen)	µg/L	-	-	60	9.9	14	20	43	**110**	**250**	**93**	**110**	**91**	**100**
Nitrate (as Nitrogen)	µg/L	-	550000	13000	25	25	700	1700	4800	9200	100	120	83	92
Total Ammonia (as Nitrogen)	µg/L	-	-	689	25	25	380	610	**790**	**1400**	140	160	130	150
Un-ionized Ammonia (as Nitrogen)	µg/L	500	-	19	0.064	0.097	14	**23**	**30**	**53**	5	6	5	6
Cyanide, Total	µg/L	500	-	-	10	10	10	10	10	10	10	10	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.1	1.2	1	1	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	1000	1000	170000	290000	160000	260000	21000	24000	46000	47000
Fluoride	µg/L	-	-	120	60	60	60	60	**220**	**260**	80	85	68	70
Radium-226	Bq/L	0.37	-	-	0.005	0.005	0.0050	0.0050	0.021	0.025	0.0073	0.0078	0.0110	0.0110
Temperature	°C	-	-	-	12.0	17.0	9.2	17	9.3	18	9.1	18	10	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	8.8	9.7	300	480	99000	120000	11000	14000	6800	7800
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.0	6.9	7.8	7.6	7.8	7.6	7.3	7.2	7.4	7.3
Hardness (as $CaCO_3$)	mg/L	-	-	-	8.4	8.7	200	290	220	280	41	44	64	64
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.0	4.1	4.9	1.4	1.5	1.2	1.2

Notes:

MDMER - Metal and Diamond Mining Effluent Regulations (Canada), Table 1 of Schedule 4, Maximum Authorized Monthly Mean Concentrations (SOR/2002-222 2020).

CWQG - Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life, short-term and long-term (CWQG-FAL referred to as CWQG) by Canadian Council of Ministers of the Environment (CCME 2020).

Concentrations exceeding MDMER are highlighted gray, CWQG short-term are double underlined, and CWQG long-term are bold.

For further details on the parameters and guidelines see Table C-1 notes in Appendix 7B of the EIS.

Table 11: The highest value of the monthly mean and 95th %-ile for each project phase in pit water in the sensitivity model.

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	16	22	20	29	**190**	**270**	99	**110**	**120**	**120**
Antimony	µg/L	-	-	-	0.5	0.5	0.50	0.50	2.9	3.5	0.9	0.9	0.68	0.71
Arsenic	µg/L	100	-	5	0.5	0.5	1.4	2.1	2.6	3.4	2.2	2.3	2.2	2.3
Barium	µg/L	-	-	-	2.3	3	5.2	7.6	14	17	4	4	4	5
Boron	µg/L	-	29000	1500	25	25	25	25	26	28	25	25	25	25
Cadmium	µg/L	-	0.13	0.04	0.01	0.01	0.010	0.015	0.033	0.038	0.018	0.020	0.015	0.017
Calcium	µg/L	-	-	-	2800	2900	68000	98000	68000	88000	13000	14000	22000	22000
Chromium	µg/L	-	-	1	1.1	1.9	**1.1**	**1.8**	**1.5**	**2.4**	**1.4**	**1.9**	**1.3**	**1.9**
Copper	µg/L	100	-	2	0.6	0.9	1	1.3	**6.5**	**7.8**	1.7	1.8	1.3	1.4
Iron	µg/L	-	-	300	25	25	**480**	**880**	**440**	**800**	210	230	**320**	**330**
Lead	µg/L	80	-	1	0.25	0.25	0.25	0.25	0.30	0.34	0.25	0.26	0.25	0.25
Magnesium	µg/L	-	-	-	340	350	6500	9800	6300	8900	1500	1600	2200	2200
Manganese	µg/L	-	596	210	5.5	6.8	**620**	**1100**	**510**	**840**	160	170	190	200
Mercury	µg/L	-	-	0.026	0.007	0.007	0.007	0.007	**0.04**	**0.05**	0.014	0.015	0.011	0.012
Molybdenum	µg/L	-	-	73	1.0	1.0	5.6	8.0	9	11	2	2	3	3
Nickel	µg/L	250	-	25	1.0	1.0	1.0	1.0	3.0	3.7	1.2	1.3	1.0	1.1
Phosphorus	µg/L	-	-	4	50	50	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	95	130	600	860	4500	5300	510	570	400	420
Selenium	µg/L	-	-	1	0.25	0.25	0.38	0.39	0.6	0.7	0.44	0.46	0.41	0.42
Silver	µg/L	-	-	0.25	0.05	0.05	0.050	0.050	0.16	0.19	0.066	0.069	0.056	0.058
Sodium	µg/L	-	-	-	1400	1500	42000	70000	37000	64000	6000	6600	11000	12000
Thallium	µg/L	-	-	0.8	0.05	0.05	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
Uranium	µg/L	-	33	15	0.05	0.05	0.78	0.92	4.0	4.8	0.5	0.5	0.40	0.42
Zinc	µg/L	400	11.3	2.2	2.5	2.5	**2.5**	**2.5**	**28**	**33**	**8.2**	**8.9**	**6.6**	**7.0**
Chloride	µg/L	-	640000	120000	2400	2600	36000	59000	33000	48000	5300	5900	9200	9400
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	38	53	720	1800	4900	9400	100	120	83	91
Nitrite (as Nitrogen)	µg/L	-	-	60	9.9	14	20	43	**110**	**250**	**93**	**110**	**91**	**100**
Nitrate (as Nitrogen)	µg/L	-	550000	13000	25	25	700	1700	4800	9200	100	120	83	92
Total Ammonia (as Nitrogen)	µg/L	-	-	689	25	25	380	610	**790**	**1400**	140	160	130	150
Un-ionized Ammonia (as Nitrogen)	µg/L	500	-	19	0.064	0.097	14	**23**	**30**	**53**	5	6	5	6
Cyanide, Total	µg/L	500	-	-	10	10	10	10	10	10	10	10	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.1	1.2	1	1	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	1000	1000	170000	290000	160000	260000	22000	25000	46000	47000
Fluoride	µg/L	-	-	120	60	60	60	60	**190**	**220**	77	80	67	69
Radium-226	Bq/L	0.37	-	-	0.005	0.005	0.0050	0.0050	0.017	0.020	0.0070	0.0072	0.0110	0.0110
Temperature	°C	-	-	-	12.0	17.0	9.2	17	9.3	18	9.1	18	10	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	8.8	9.7	290	470	75000	91000	9200	10000	6700	7700
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.0	6.9	7.8	8.0	7.8	8.0	7.3	7.5	7.4	7.5
Hardness (as $CaCO_3$)	mg/L	-	-	-	8.4	8.7	200	290	200	260	39	42	64	64
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.0	3.4	4.0	1.3	1.4	1.1	1.2

Notes:

MDMER - Metal and Diamond Mining Effluent Regulations (Canada), Table 1 of Schedule 4, Maximum Authorized Monthly Mean Concentrations (SOR/2002-222 2020).

CWQG - Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life, short-term and long-term (CWQG-FAL referred to as CWQG) by Canadian Council of Ministers of the Environment (CCME 2020).

Concentrations exceeding MDMER are highlighted gray, CWQG short-term are double underlined, and CWQG long-term are bold.

For further details on the parameters and guidelines see Table C-1 notes in Appendix 7B of the EIS.

Table 12: Concentration ratios between the sensitivity and EIS models for open pit.

Parameter	Baseline		Construction		Operation		Closure		Post-closure	
Statistics	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	1.0	1.0	1.0	1.0	0.9	0.9	1.0	1.0	1.0	1.0
Antimony	1.0	1.0	1.0	1.0	0.8	0.7	0.9	0.8	1.0	0.9
Arsenic	1.0	1.0	1.0	1.0	0.8	0.9	1.0	1.0	1.0	1.0
Barium	1.0	1.0	1.0	1.0	0.8	0.8	0.9	0.9	1.0	1.0
Boron	1.0	1.0	1.0	1.0	0.8	0.7	1.0	1.0	1.0	1.0
Cadmium	1.0	1.0	1.0	1.0	**1.3**	**1.3**	1.1	1.1	1.0	1.1
Calcium	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	1.0	1.0
Chromium	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Copper	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Iron	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lead	1.0	1.0	1.0	1.0	1.1	1.1	1.0	1.0	1.0	1.0
Magnesium	1.0	1.0	1.0	1.0	0.9	0.9	1.0	0.9	1.0	1.0
Manganese	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mercury	1.0	1.0	1.0	1.0	1.1	1.1	1.0	1.0	1.0	1.0
Molybdenum	1.0	1.0	1.0	1.0	0.7	0.7	0.9	0.8	1.0	1.0
Nickel	1.0	1.0	1.0	1.0	**2.3**	**2.2**	1.2	1.2	1.0	1.1
Phosphorus	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Potassium	1.0	1.0	1.0	1.0	0.8	0.8	0.9	0.8	1.0	1.0
Selenium	1.0	1.0	1.0	1.0	0.8	0.7	1.0	1.0	1.0	1.0
Silver	1.0	1.0	1.0	1.0	0.8	0.8	1.0	0.9	1.0	1.0
Sodium	1.0	1.0	1.0	1.0	0.9	1.0	1.0	0.9	0.9	1.0
Thallium	1.0	1.0	1.0	1.0	0.9	0.8	1.0	1.0	1.0	1.0
Uranium	1.0	1.0	1.0	1.0	0.8	0.7	0.8	0.7	1.0	1.0
Zinc	1.0	1.0	1.0	1.0	**2.2**	1.0	**1.2**	1.0	1.1	1.0
Chloride	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Nitrate + Nitrite (as Nitrogen)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Nitrite (as Nitrogen)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Nitrate (as Nitrogen)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total Ammonia (as Nitrogen)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Un-ionized Ammonia (as Nitrogen)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cyanide, Total	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cyanide, WAD	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sulphate	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Fluoride	1.0	1.0	1.0	1.0	0.9	0.8	1.0	0.9	1.0	1.0
Radium-226	1.0	1.0	1.0	1.0	0.8	0.8	1.0	0.9	1.0	1.0
Temperature	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total Alkalinity (as $CaCO_3$)	1.0	1.0	1.0	1.0	0.8	0.8	0.8	0.7	1.0	1.0
pH (mean or 5 %ile)	1.0	1.0	1.0	1.1	1.0	1.1	1.0	1.0	1.0	1.0
Hardness (as $CaCO_3$)	1.0	1.0	1.0	1.0	0.9	0.9	1.0	1.0	1.0	1.0
Dissolved Organic Carbon	1.0	1.0	1.0	1.0	0.8	0.8	0.9	0.9	0.9	1.0

Note: Ratios above 1.2 are bold and highlighted gray.

APPENDIX IR-25.A
IR-25 SGS REPORT

Excerpt from Report

An Investigation of

GOLD RECOVERY FROM VALENTINE LAKE PROJECT ORES

prepared for

MARATHON GOLD

Project 16863-01 (includes 16863-03) – Report 2 of 3 - Milling
April 15, 2020

NOTES

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Table 67: Comparison of the Overall Metallurgy Achieved in FS-1 and FS-2, VLMC Tests

Flowsheet 1		**Comp VLMC**	**Difference Between Flowsheets**
Primary Grind P_{80}, µm	=	153	--
Direct Head, Au g/t	=	2.35	0.00
Calc Head, Au g/t	=	2.81	-0.20
Au Recovery / Extraction			
Gravity Separation (G25), %	=	**72.9**	14.1
Flotation Concentrate, %	=	*20.1*	--
Flotation Tailing, %	=	*7.0*	--
Flotation Concentrate CN (Avg. of CN3 and 4), %	**=**	**17.0**	--
Flotation Tailing CN (Avg. of CN5 and 6), %	**=**	**5.1**	--
Combined FS-1 Circuit Au Recovery, %	**=**	**94.9**	**0.1**
NORM. to DIRECT Head, %	**=**	***94.1***	**0.7**
NORM. to AVG. Calc Head, %	**=**	***95.3***	**0.6**
Final Comb FS-1 Tailing (Avg. of CN3-6), Au, g/t	=	0.14	-0.02
Flowsheet 2		**VLMC**	**Difference Between Flowsheets**
Primary Grind P_{80}, µm	=	73	--
Direct Head, Au g/t	=	2.35	0.00
Calc Head, Au g/t	=	3.01	0.20
Au Recovery / Extraction			
Gravity Separation (G26), %	=	***58.8***	**-14.1**
Gravity Tailing CN (Avg. of CN7 and 8), %	=	***36.0***	
Combined FS-2 Circuit Au Recovery, %	**=**	**94.8**	**-0.1**
NORM. to DIRECT Head, %	**=**	***93.4***	**-0.7**
NORM. to AVG. Calc Head, %	**=**	***94.7***	**-0.6**
Final Comb FS-2 Tailing (Avg. of CN7 and 8), Au, g/t	=	0.16	0.02

The average gold recovery advantage shown for FS-1 in the above table is less than that calculated for the tests on the Low- Grade Variability samples (Table 56) although the difference in tailings grade remains at 0.02 g/t.

3. Cyanide Detoxification Testwork

3.1. Bulk Cyanide Leaching

Two cyanide detoxification (CND) tests were performed on combined tailing representing the gravity-flotation + leach flowsheet (FS-1) bulk cyanide leached (CIL) tailing pulps from tests FCN25b and FCN26b. Cyanide leach test FCN25a was completed on 500 g of Marathon pilot plant flotation concentrate, while FCN25b was completed on 16 kg combined Marathon pilot plant flotation tailing (15.52 kg) and 0.48 kg (dry equivalent) leached residue from test FCN25a. This is equivalent to 3% reground flotation concentrate (P_{80} = 13 µm) and 97% flotation tailing (P_{80} = 147 µm).

The same mass proportions of Leprechaun deposit pilot plant products were used to generate the FCN26b CIL tailing used in the corresponding CND testwork. Reground flotation concentrate and “as-is” flotation tailing P_{80}’s were 12 µm and 154 µm, respectively.

Cyanide detoxification tests were not undertaken on tailings representing the gravity + tailing cyanide leach process option.

Final CIL barren pulps were subsampled to generate a metallurgical balance and to provide the required analyses (Cu, Fe, CN_T, and CN_{WAD}) for the subsequent detoxification testing. Leach test conditions applied were as follows:

Table 68: CN Leach Conditions, Flot Concentrate, and Combined Flot Conc + Tail

		Flot Conc CN's, FCN25a and FCN26a	Flot Conc + Flot Tail. FCN25b and FCN26b	
Pulp Density	=	40	50	% Solids (w/w)
Pulp pH	=	11-11.5	10.5-11	Maintained with lime
Cyanide Concentration	=	10	--	g/L NaCN, maintained for 12 hours
Cyanide Concentration	=	--	0.3	g/L NaCN maintained @ 0.2 g/L
Carbon Concentration	=	20	5	g/L, Preattritioned Calgon GRC 22
Leach Retention Time	=	36	24	hours

Test results are presented in Table 69 and Table 70 for the concentrate and combined tailing + concentrate leaches, respectively.

Table 69: Bulk PP Flotation Concentrate CIL Results

PP Flot Conc	Test	Feed Size P_{80}, µm	Reagents (kg/t of CN Feed) Added		Consumed		36 h Au Extraction %	Leach Residue Au, g/t	Head Grade, Au, g/t	
			NaCN	CaO	NaCN	CaO			Calc.	Direct
Marathon	FCN25a	13	23.8	0.88	10.5	0.43	**97.9**	0.56	26.8	27.3
Leprechaun	FCN26a	12	28.4	0.83	18.4	0.05	**97.8**	0.68	31.5	59.3

Table 70: Bulk PP Flotation Tailing + Preleached PP Concentrate CIL Results

PP Flot Tail + (leached) Flot Conc	Test	Feed Size P_{80}, µm	Reagents (kg/t of CN Feed) Added		Consumed		24 h Au Extraction %	Leach Residue Au, g/t	Head Grade, Au, g/t, Calc.
			NaCN	CaO	NaCN	CaO			
Marathon	FCN25b	153	0.30	0.27	0.08	0.27	**52.3**	0.09	0.19
Leprechaun	FCN26b	142	0.3	0.21	0.10	0.21	**59.2**	0.10	0.25

In all respects, the bulk leaching to generate feed for cyanide detoxification tests presented above, performed as expected and confirms the results of the development work presented earlier.

3.2. SO_2/Air Cyanide Destruction

Conventional SO_2/air cyanide detoxification was applied to barren leached tailing slurries generated as described above.

3.2.1. Background

The chemical reaction for the oxidation of weak-acid dissociable cyanide (CN_{WAD}) using sodium metabisulphite ($Na_2S_2O_5$) as the source of SO_2, and air as the source of oxygen, proceeds as follows:

$$2\ CN^- + Na_2S_2O_5 + 2\ O_2 + 2\ OH^- \rightarrow 2\ CNO^- + Na_2SO_4 + SO_4^{2-} + H_2O$$

This reaction is catalyzed by the presence of copper. The feed usually contains some copper (as the copper cyano complexes), and if required, additional copper is added as copper sulphate. Hydrated lime is added to the reactor to provide the hydroxide ion for the above reaction.

The base metals (such as copper, zinc and nickel) that previously complexed with the cyanide are liberated and precipitated as metal hydroxides:

$$Cu^{2+} + 2OH^- \rightarrow Cu(OH)_2$$

Ferrocyanide is not destroyed in the process and is instead precipitated with other base metals such as copper, zinc and nickel as mixed metal ferrocyanide solids:

$$Fe(CN)_6^{4-} + 2Cu^{2+} \rightarrow Cu_2Fe(CN)_6$$

$$Fe(CN)_6^{4-} + 2Zn^{2+} \rightarrow Zn_2Fe(CN)_6$$

Thiocyanate, if present, is partially oxidized to cyanate and sulphate:

$$SCN^- + Na_2S_2O_5 + 3O_2 + 4OH^- \rightarrow CNO^- + Na_2SO_4 + 2SO_4^{2-} + 2H_2O$$

The cyanate ion is unstable, and slowly hydrolyzes to ammonium and carbonate ions:

$$CNO^- + 2\ H_2O \rightarrow CO_3^{2-} + NH_4^+$$

The rate of hydrolysis of the cyanate ion increases with decreasing pH. The carbonate ion precipitates as calcium carbonate. A small amount of the ammonium ion is found to form ammonia (NH_3) and eventually escapes from the solution as NH_3 gas.

The standard procedure for cyanide detoxification using SO_2/air in a bulk-batch mode was applied. A 1 L reactor equipped with baffles and air sparger was first filled with the feed pulp. The required amount of copper sulphate was added based on the analysis completed prior to testing. The pulp was treated in batch mode with $Na_2S_2O_5$ and air to reduce the concentration of CN_{WAD} in solution to approximately 1 mg/L.

The oxidation reduction potential (ORP) of the pulp was monitored with a Pt/Ag/AgCl combination electrode, while the residual CN_{WAD} concentration in the solution phase was monitored during the test using the picric acid method. At the end of each test, a solution sample was taken for analysis of CN_T, CN_{WAD}, copper and iron.

Once the batch of pulp has been treated and cyanide destroyed to the target level, the continuous test commenced. Slurry was pumped to the vessel (1 L reactor) at a rate determined by the target residence time requirement (typically, and in this case, ~60 minutes), and reagents ($Na_2S_2O_5$ and lime) and air were added continuously. Samples of solution phase of the slurry discharge were taken periodically and analysed for CN_T, CN_{WAD}, copper and iron to determine the efficiency of the CND reaction.

It should be noted that batch tests are inefficient and should only be used for determining the amenability of the sample to treatment using SO_2/air and providing a rather conservative indication of reagent requirements. Continuous testing is required for optimization of parameters such as retention time and reagent dosages. In addition, sodium metabisulphite, a partially neutralized form of SO_2, is generally used in laboratory testing to allow accurate addition of the reagent. It is anticipated that in a commercial plant using SO_2 gas, the lime requirement for pH control may require an additional 0.5 mole lime per mole SO_2, or 0.58 g lime per g SO_2 as suggested by the following chemical reactions:

$$2SO_2 + 2NaOH \rightarrow Na_2S_2O_5 + H_2O$$

$$Na_2S_2O_5 + Ca(OH)_2 \rightarrow CaSO_3 + Na_2SO_3 + H_2O$$

$$2SO_2 + 2Ca(OH)_2 \rightarrow 2CaSO_3 + 2H_2O$$

3.2.2. Results

Results are presented in Table 71 and details are included in Appendix C.

Table 71: SO_2/Air Cyanide Detoxification Summary

Test Number	Test Dur., min.	Reten. Time, min	Product (Solution Phase) pH	Analysis, mg/L CN_T	CN_{WAD} by Ana. Lab	CN_{WAD} by Picric Acid	Cu	Fe	Reagent Addition g/g CN_{WAD} SO_2 Equiv.	g/g CN_{WAD} Lime (CaO)	g/g CN_{WAD} Cu[1]	g/L Feed Slurry SO_2 Equiv.	g/L Feed Slurry Lime (CaO)	g/L Feed Slurry Cu[1]	kg/t Solids SO_2 Equiv.	kg/t Solids Lime (CaO)	kg/t Solids Cu[1]
Marathon, *Feed from FCN25b*			*9.8*	*200*	*137*		*15.7*	*30.5*									
CND 1 Batch Test	130	130	8.5	--	--	0.69	--	--	4.75	7.11	0.47	0.48	0.72	0.05	0.65	0.97	0.06
Continuous Tests																	
1-1	410	57	8.6	5.00	0.10	0.54	0.1	1.8	4.68	3.66	0.46	0.47	0.38	0.05	0.64	0.50	0.06
1-2	240	52	8.6	9.24	0.14	0.63	0.3	3.4	4.80	3.21	**0.36**	0.48	0.33	0.04	0.66	0.44	0.05
1-3	185	59	8.5	19.8	0.08	1.03	0.6	6.3	4.82	2.80	**0.22**	0.49	0.29	0.02	0.66	0.38	0.03
1-4	430	54	8.5	29.7	0.10	1.69	1.8	10.7	**4.39**	3.02	0.23	0.44	0.31	0.02	0.60	0.41	0.03
Leprechaun, *Feed from FCN26b*		--	*10.3*	*300*	*112*		*15.6*	*72.7*									
CND 2 Batch Test	230	230	8.5	--	--	0.79	--	--	8.55	13.8	1.50	0.71	1.14	0.12	0.96	1.54	0.17
Continuous Tests																	
2-1	410	60	8.5	0.2	<0.01	0.32	0.4	0.2	**4.25**	3.83	1.75	0.35	0.32	0.14	0.48	0.43	0.20
2-2	240	57	8.5	4.02	<0.01	0.67	0.2	1.5	4.32	2.69	**1.39**	0.36	0.23	0.11	0.48	0.30	0.16
2-3	190	54	8.8	24.9	<0.01	1.40	0.3	9.1	4.28	2.30	**0.88**	0.35	0.19	0.07	0.48	0.26	0.10
2-4	370	56	8.8	6.90	<0.1	2.19	0.1	0.2	4.46	1.94	1.00	0.37	0.16	0.08	0.50	0.22	0.11

-- No sample submitted for assays

(1) Cu added as copper sulphate ($CuSO_4 \cdot 5H_2O$), SO_2 added as sodium metabisulphite ($Na_2S_2O_5$)

The 4.75 g SO_2/g CN_{WAD}, added in CND 1 batch test, and similarly added in all but the last trial on FCN25b (Marathon) feed (CND 1-4) is the fairly standard starting dosage (ratio) after initial batch treatment to the approximate detoxification target. Running at that concentration in the batch treatment stage and in the initial three (of four) continuous runs resulted consistently in CN_{WAD} contents of less than the target of ~1 mg/L (CN_{WAD} analyses by the higher precision methods applied in the SGS Minerals analytical laboratory). Reducing the SO_2 dosage somewhat, to ~4.4 g SO_2/g CN_{WAD}, in the final trial (CND 1-4) yielded similarly low CN_{WAD} after only 54 minutes of retention (less than the reporting limit of 0.1 mg/L CN_{WAD}).

While a considerably higher SO_2 dosage (8.55 g SO_2/g CN_{WAD}) was required to batch treat FCN26b (Leprechaun) pulp to the target range, dosages in the continuous phase were consistently <4.5 g SO_2/g CN_{WAD} in the continuous trials. The CN_{WAD} analyses by the higher precision methods applied in the SGS Minerals analytical laboratory indicated that all trials yielded CN_{WAD} values less than the detection limit (= 0.01 or 0.1 mg/L depending on unspecified interferences).

The principal parameter examined in this testwork was copper dosage. Copper, as explained in the preamble above, is required at a certain concentration to catalyse the detoxification reaction. In both cases, copper addition (as copper sulphate) was reduced by a factor of two without negatively impacting the principal reaction. Copper addition was reduced from 0.46 to 0.23 g/g CN_{WAD} in CND1 and from 1.75 to 0.88 g/g CN_{WAD} in CND2. The reduction in copper sulphate addition had a positive impact on reducing lime requirement.

Cyanide detoxification testwork clearly indicated that the CN_{WAD} present in the CIL barren slurries was easily destroyed to levels below the typical effluent discharge requirement of <1 mg/L CN_{WAD} (to the environment). On all accounts these results must be considered as excellent. As the primary purpose of these tests was to generate material for environmental analysis, SGS did not determine absolute minimal dosage requirements for either SO_2 or copper. Future testwork, if undertaken, should examine further reducing SO_2 dosage, copper dosage and retention time. Based on the data presented here, further reductions are probable.

The final detoxified slurries were turned over to the custody of the SGS Mining Environmental group for a series of short and long term tests. That work was administered, and has been reported, under a separate test program (16863-02) and is not included in this report.