Appendix 31

Meadowbank and Whale Tail 2018 Core Receiving Environment Monitoring Program

2018 Core Receiving Environment Monitoring Program

Meadowbank Mine and Whale Tail Project

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REPORT ORGANIZATION

The 2018 Core Receiving Environment Monitoring Program (CREMP) report is organized into a main document and 8 appendices (A through H). The document underwent a significant restructuring in 2018 with the integration of the Whale Tail Project into the annual CREMP report. An overview of the various sections of the report is provided to help guide the reader as they navigate the document.

Executive Summary provides a high-level summary of the 2018 monitoring results by study area (Meadowbank, Whale Tail, and Baker Lake).

Section 1 introduces the CREMP with overview of the environmental setting for the project. The pace and scope of mining development is also outlined to catalogue how the CREMP has been implemented to monitor changes in the aquatic receiving environment.

Section 2 outlines elements of the CREMP study design including sampling areas, a description of the routine monitoring components, details regarding any targeted studies conducted for a given cycle, and the statistical framework used to assess spatial and temporal changes in chemistry (water and sediment) and biological communities (phytoplankton and benthic invertebrates).

Section 3 summarizes results of the detailed quality assurance and quality control assessment (QA/QC) presented in **Appendix A**.

Section 4 (Meadowbank), **Section 5** (Whale Tail Pit) and **Section 6** (Baker Lake) are stand-alone chapters detailing the results of the spatial and temporal trends in water quality, sediment chemistry, and biological community health (phytoplankton and benthos) specific to each study area. Figures and Tables are included at the end of each section.

Section 7 provides recommendations for the scope of the 2019 CREMP for Meadowbank, Whale Tail, and Baker Lake study areas.

EXECUTIVE SUMMARY

The CREMP focuses on identifying changes in limnology, water and sediment chemistry, and primary (phytoplankton) and secondary (benthic invertebrate community) aquatic producers that may be associated with mine development activities. This is accomplished through the application of a temporal/spatial trend assessment that includes application of quantitative decision criteria (i.e., early warning “triggers” and action “thresholds”) to facilitate immediate and objective decision-making regarding appropriate management actions. CREMP results are integrated annually into the Aquatic Ecosystem Monitoring Program (AEMP) for holistic environmental management and decision making.

Meadowbank

The 2018 CREMP results for the Meadowbank study area are presented below and summarized in **Table ES-1**.

Water Quality

Full water quality monitoring (i.e., limnology and water chemistry) was completed in May, July, August, September and November according to the monitoring strategy for the program. Limnology profiles were taken at the NF areas (TPN, TPE, SP, WAL) in the winter months when ice conditions were safe to verify there were no anomalous changes in water quality (e.g., conductivity) attributable to site-related activities.

Similar to previous years, statistically significant mine-related changes continue to be detected relative to baseline/reference conditions at one or more near-field (NF) areas for alkalinity (TPE, SP); conductivity (TPN, TPE, SP, WAL); hardness (TPN, TPE, SP, WAL); major cations (i.e., calcium, potassium, magnesium, and sodium [TPN, TPE, SP, WAL]); and TDS (TPN, TPE, SP, WAL). In the absence of effects-based thresholds (e.g., CCME water quality criteria) for these parameters, their triggers were set at the 95th percentile of baseline data. While these results represent mine-related changes, the observed concentrations are still relatively low and there is no evidence to suggest concentrations are increasing year-over-year or that the observed concentrations would result in adverse ecological effects. Consistent with previous reporting cycles, there were no trigger exceedances in 2018 for any water quality parameters with CCME water quality guidelines, including metals. In the context of the FEIS, the magnitude of potential effect on water quality in each of the near-field lakes in 2018 was considered low (i.e., less than 1x the CCME WQGs) and consistent with predictions. **Routine water quality monitoring is recommended for 2019**, consistent with recent CREMP cycles in 2015 to 2018.

Phytoplankton Community

Water samples for phytoplankton taxonomy analyses were carried out synoptic with the water chemistry sampling program in 2018. Phytoplankton biomass was statistically significantly higher at WAL in 2018 relative to reference/baseline conditions. The observed increase in the BACI assessment was not linked back to any observable site-related activities given there was no discharge of water to WAL in 2018. Nutrient concentrations in WAL remain well below levels associated with increased primary productivity. The absolute biomass values at the NF are in line with their historical values. Taking into consideration all the lines of evidence (BACI and absolute values plotted over time), there is no evidence to suggest mining operations are increasing primary productivity in the NF areas. Phytoplankton richness was similar to previous monitoring cycles. **The trends in phytoplankton biomass and richness will be reviewed again in 2019**.

Sediment Chemistry

Quantitative trigger analysis was completed on metals data from the follow-up targeted sediment coring program at TPE and WAL to verify the apparent increases in sediment metals concentrations observed in 2017. Grab samples were also submitted for analysis from the NF and reference areas in 2018 for analysis of habitat variables (particle size and TOC), metals, and organics analysis on the top 3-5 cm of sediment.

- **TPE** – Chromium concentrations at TPE increased steadily between 2009 and 2013. The suspected cause of the increase is ultramafic rock used to construct the Bay-Goose Dike in 2009 and 2010. Chromium exceeded the trigger value in 2018, but the concentrations were less than those reported in 2017. Natural sedimentation rates in these lakes are low, and the lower reported chromium concentrations in 2018 (which were also seen in 2016) suggest chromium concentrations can vary significantly over a small spatial area. There is conclusive evidence that chromium has increased in the sediments at TPE relative to the baseline period; however, high annual variability in chromium concentrations observed between 2017 and 2018 suggests concentrations have stabilized. **A repeat of the coring program is recommended in 2019 to provide three-consecutive years of core chemistry data for interpreting the temporal trend in chromium concentrations.**
- **WAL** – 2017 was the first year of BA analysis of sediment core chemistry at WAL. Arsenic, and to a lesser extent chromium and lead exceeded the trigger values specific to WAL in 2017, but there was uncertainty about whether the exceedances were indicative of a "real" temporal trend or an artefact of spatial heterogeneity in metals concentrations. The 2018 core chemistry results were exceeded the trigger value for arsenic. Chromium and lead were less than their respective trigger values in 2018 (i.e., within the range of baseline concentrations). In the case of arsenic, the mean concentration was lower in 2018 (46.6 mg/kg) compared to 2017 (61.8 mg/kg). These results confirm that there is considerable spatial variability with the sediment basin in WAL. **No follow-up**

studies are recommended for WAL, TPN, or SP in 2019 beyond routine sediment grab sampling to support the benthos community assessment.

Benthos Community

The only statistically significant change to the benthic invertebrate community at Meadowbank identified by the BACI assessment in 2018 was for a reduction in total abundance for the three-year (2016 to 2018 [-48%; p = 0.07]) and four-year (2015 to 2018 [47%; p = 0.04]) time periods at TPE relative to baseline/reference conditions. That result, however, appears to be due mainly to particularly high abundance at INUG in recent years relative to its baseline years rather than on actual reductions at TPE. Absolute total abundance at TPE in 2018 (~2,500 organisms/m^2) was stable relative to the range of values dating back to 2012 (2,220 to 3,100 organisms/m^2) and was well within its baseline range. The regional increase in abundance assumed by the BACI model based on the pattern at INUG is not apparent at reference area PDL. Furthermore, there were no statistically significant changes in taxa richness, a key metric for metals-related effects due to the loss of sensitive taxa. Richness at TPE has remained consistent throughout the monitoring period, indicating that mining activities are not adversely affecting the structure of the benthic invertebrate community. Collectively, these results suggest that the apparent reduction in total abundance at TPE is most likely an artefact of the BACI model rather than a real ecological change to the benthic community.

Sediment Metals Bioavailability

Targeted studies were also completed at TPE in 2018 to further assess mining-related changes to sediment chromium concentrations at TPE. As described above for sediment chemistry, chromium concentrations (grab and core samples) appear to have stabilized since 2013, but the variability observed since then is evidence of small-scale spatial heterogeneity. A bioavailability study (consisting of geochemical sequential extraction analyses and sediment toxicity test) conducted in 2015 showed low metals availability and low toxicity. This study (minus the sequential extraction analyses) was repeated in 2018. Key finds from the 2018 study are:

- Sediment toxicity testing results from the 2018 amphipod test suggest metals might be increasing in their bioavailability compared to 2015. The amphipod test showed substantial effects to survival that were not correlated to sediment chromium concentrations. The cause of impaired survival in TPE sediments is unclear, but the results suggest other exposure pathways (e.g., porewater) or stressors (e.g., physical or chemical) may be responsible for the toxicity seen in 2018. Confounding the assessment is the fact that three of the five replicates in the amphipod test had complete mortality, while one had 100% survival.
- The chironomid test did not show any effects to survival at TPE in 2018, but did have reduced growth (-21%) relative to the field controls (INUG/PDL). Given their dominance in the benthic

invertebrate communities of the Meadowbank study lakes, the chironomid toxicity test results are considered more ecologically relevant for this site.

A weight-of-evidence approach was used to integrate the results of the routine and targeted studies at TPE in 2018. While there was some toxicity to chironomids (reduced growth), the highest weight was applied to the field survey data for the benthic community at TPE, which showed stable or improving results for total abundance and taxa richness over the last six years that were consistent with the baseline range. That said, there are uncertainties regarding the exact cause of the observed effects to *H. azteca* survival in 2018 that warrant follow-up in 2019 to provide added assurance that bioavailability is not changing at TPE. Amphipods are not reflected in the natural benthos community present in the study areas; however, as an "indicator" taxon, the results from 2015 and 2018 provide important information about how exposure conditions have changed over time. *H. azteca* is more sensitive to the effects of pollution than *C. dilutus*, and from a site management perspective, the *H. azteca* test results serve as the equivalent of an "early warning trigger" for detecting changes in sediment chemistry before more ecologically significant effects to *C. dilutus* are detected. **Two recommendations for 2019 to help better understand risks to the benthic invertebrate community at TPE: (1) continue scrutiny of trends in benthic invertebrate abundance and richness at TPE, and (2) repeat the sediment toxicity testing (chironomid and amphipod tests) at TPE in 2019 with the addition of porewater sampling to try to determine the cause of the reduced chironomid growth and amphipod survival in TPE sediments.**

Whale Tail

The 2018 CREMP results for the Whale Tail study area are presented below and summarized in **Table ES-2**.

The Whale Tail Project was merged with the Meadowbank and Baker Lake CREMP reporting framework in 2018. Baseline data collection continued for most of the study area lakes in 2018. With the onset of in-water construction activities in Whale Tail Lake, Whale Tail Lake -South Basin (WTS) and Mammoth Lake (MAM) transitioned from control to impact designations in late July and November, respectively. While no major in-water construction activities occurred in Mammoth Lake in 2018, road construction and quarry development adjacent to the lake in the fall had the potential to affect downstream water quality in this lake; subtle changes in water quality were observed in the November sampling event. The focus on the 2018 reporting effort the Whale Tail study area lakes was on describing current conditions in the context of baseline data collected for the Project using plots of the various endpoints over time. A stats approach to comparing potential changes at WTS was considered unnecessary for assessing changes in 2018 and supporting management decisions in 2019. Given the limited amount of data in the "after" period and the absence of site-specific triggers and thresholds, this year's assessment of spatial and temporal trends focused on visual identification of construction-related changes (i.e., emphasis on

WTS and MAM relative to the rest of the areas). Future assessments will follow the same process used for Meadowbank (i.e., use of triggers/thresholds and formal statistical testing of trends).

Water Quality

Water quality reported from the first half of 2018 was broadly representative of baseline conditions observed between 2014 and 2017 at the six Whale Tail study areas.

Construction activities started in late July and resulted in some predictable changes in water quality at WTS during the open water construction season. TSS concentrations measured at 2 mg/L in the August sampling event were below the Meadowbank specific trigger value of 3 mg/L. By September, TSS was trending lower and was <1 mg/L (MDL) in the samples collected in November. Concurrent with the modest increase in TSS in August was an increase in the number of parameters that were > MDL and an increase in the absolute concentration of some parameters. Increases total metals such as aluminum, chromium and iron were correlated with increased TSS in August, but the observed increase was short-lived; by November, the concentrations were back to the range reported during the baseline period. Importantly, there were no measured exceedances of the CCME water quality guidelines for parameters with effects-based thresholds at WTS in 2018, indicating the transient spike in some metals were unlikely to adversely affect aquatic life.

Mammoth Lake (MAM) water quality showed similar seasonal trends in 2018 compared to the baseline period, but in November there was evidence to suggest construction or other site-related activities were resulting in changes in some water quality parameters. The apparent changes were first noticed in the specific conductivity profile from the northeast corner of MAM in November. The upper limit for conductivity at MAM is approximately 75 µS/cm; in November the readings taken at 1 m intervals measured 100 µS/cm near the surface and increase to 150 µS/cm near the bottom. A similar pattern was observed in the December profile taken at the same location in the northeast corner of the lake. The spatial extent of changes in MAM water quality did not extend throughout the lake based on the specific conductivity results from the second profile collected in November at the other basin in MAM.

Among the parameters measured in the November water samples, hardness, TDS, nutrients (e.g., nitrate and phosphorus), metals (e.g., total and dissolved aluminum, total chromium, and total iron) were measured at higher concentrations compared to earlier in the year and compared to baseline November events in 2016 and 2017. Similar to WTS, there were no measured exceedances of the CCME water quality guidelines for parameters with effects-based thresholds.

The available data from 2018 show the spatial extent of the construction related changes in water quality did not extend downstream from MAM to Lake A76. NEM, A20 and Lake DS1 were similarly kept in the “control” phase for the duration of 2018.

Routine water quality monitoring is recommended for 2019 with analysis of the data using the same BACI statistical assessment used for Meadowbank.

Phytoplankton Community

Phytoplankton taxonomy analyses were carried out synoptic with the water chemistry sampling program in 2018. Phytoplankton communities vary naturally throughout the year in total biomass (and density) and community composition (taxa richness). The primary site-related stressors that have the potential to affect the phytoplankton community included nutrient loading and increased concentrations of metals. Nutrient loading can manifest as an increase in total biomass or a change in community structure, while effects to increasing metals would be expected to result in lower biomass and taxa diversity. Overall there was no evidence to suggest site-related activities caused changes in primary productivity in the near-field areas (MAM and WTS) due to construction activities in 2018. **The trends in phytoplankton biomass and richness will be assessed using the BACI framework as the project continues on into the construction phase in 2019.**

Sediment Chemistry

Lakes in the Whale Tail study area have naturally-high concentrations of some metals. Arsenic, cadmium, chromium, copper, and zinc exceeded the CCME interim sediment quality guideline in at least one sample collected in 2018. Of these five metals, arsenic is particularly enriched in sediments throughout the study area lakes, with most samples exceeding the CCME probable effect level sediment quality guideline. There was no indication of a temporal increase in sediment metals concentrations at WTS (or any other area) in 2018 relative to the baseline period. Sediment core samples, which target the top 1.5 cm of sediment as opposed to the 3 to 5 cm targeted in grab samples, are preferentially used in the statistical testing of temporal trends in sediment chemistry. The next coring study is scheduled for 2020, coinciding with the normal 3-year sediment coring cycle for the CREMP. **Routine sediment grab chemistry sampling is recommended in 2019 to support the benthos community assessment and broadly assess changes in sediment chemistry over time at each area.**

Benthos Community

Benthic invertebrate (benthos) community structure (taxa richness) and function (abundance) is typical of northern headwaters lakes in the region (i.e., low abundance and few taxa). Benthos communities in these lakes have, by virtue of their presence, adapted to the naturally-elevated concentrations of metals in sediment. Although total abundance tends to be low, within-area variability can be substantial. Taxa richness, unlike abundance, is more consistent with interannual variability quite low for the various areas. The normal range of species identified among the various study areas is 10 to 15; in 2018 there were between 13 and 20 taxa identified at WTS. The comparatively high taxa richness, combined with no apparent change in abundance, demonstrates that dike construction did not alter the structure or function of the benthos community in 2018. **Routine monitoring of the benthos community is recommended in 2019,** consistent with study design outlined in the Addendum to the CREMP: 2015 Design Document (Azimuth, 2018b).

Baker Lake

CREMP monitoring at Baker Lake started in 2008. Key mine-related activities include barge/shipping traffic and general land-based activities associated with the tank farm area. Approximately double the number of barge shipments arrived at BPJ in 2018 to support construction activities for the Whale Tail Project. No spills of fuel, hydrocarbons or any other materials were reported in the vicinity of the barge dock or jetty in 2018.

Chemistry

Sampling was conducted at two near-field (BBD, BPJ) and one (BAP; water) or two (BAP, BES; sediment) areas situated along the north shore of Baker Lake in July, August, and September. There were no cases where water quality parameters exceeded the triggers in 2018, consistent with recent monitoring cycles. Metals concentrations in sediment grab samples collected to support the benthos assessment were well within previously-reported concentrations at the four locations. There was no evidence of any barge-related impacts to water quality or sediment chemistry at impact areas in Baker Lake. **The trends in water and sediment chemistry (grab) will be monitored in 2019.**

Biological Communities

The phytoplankton and benthos communities in Baker Lake have not exhibited any changes that are attributable to Agnico Eagle's activities in Baker Lake. **No follow-up management actions are required for 2019 beyond routine monitoring.**

Table ES-1. Summary of key findings from the 2018 Meadowbank CREMP.

Notes
1. Temporal and spatial trends are outlined for Monitoring Components and Variables that exceeded trigger or thresholds (i.e., apparent change from baseline)
2. Spatial scale ratings are: localized = small area within the lake/area; wide-spread = basin to whole lake
3. Causality ratings are: low = no evidence of a mine-related source; moderate = some likelihood of a mine-related source; high = the source of the change is likely mine-related.

Monitoring Component (and report section)	**Variable**	**Summary**	**Temporal and Spatial Trend Assessment**[1, 2]	**Annual CREMP Results Compared to FEIS Predictions** (Cumberland, 2005)
Limnology Section 4.2	Oxygen and Temperature	The limnology profiles collected in 2018 show dissolved oxygen and temperature readings are consistent with range of conditions typical of previous monitoring cycles.	There is no evidence to suggest seasonal fluctuation in dissolved oxygen and temperature among the NF study area lakes is attributed to mining site-related activities.	No predictions in the FEIS
	Conductivity	Specific conductivity measurements were well within the range of normal conditions defined as < 75 µS/cm for most measurements collected from the study areas in 2018. Three measurements taken at WAL from between 5 and 7 m (near bottom) were above the normal range in the May event (see **Figure 4.7**). Conductivity returned to approximately 40 µS/cm by July and remained stable for the remainder of the year.	**Spatial scale** – **localized**; slightly elevated conductivity at one of the sampling locations at WAL in the May event **Temporal trend – sporadic**; conductivity returned to normal levels in July and stayed consistently low throughout 2018. **Causality – low;** the 'apparent' increase at one sampling location in WAL in May was not considered mine related for two reasons: 1) there was no discharge to WAL in 2018 2) conductivity was higher than normal reference area PDL in the same event.	No predictions in the FEIS
Water Chemistry Section 4.3	Conventional Parameters and Major Ions	Alkalinity, conductivity, hardness, major cations and TDS exceed their trigger values at one or more NF areas in 2018. The trigger values for these parameters is set at the 95th percentile of concentrations measured during the baseline period. There are no thresholds (i.e., CCME water quality guidelines) for these parameters.	**Spatial scale – widespread;** concentrations have increased lake-wide in Third Portage from TPE to TPN and between lakes (SP and WAL). **Temporal trend – stable;** concentrations are elevated relative to the baseline period according to the BACI analysis, no evidence of-year-over-year increases (i.e., concentrations in 2018 are similar to 2017, 2016, 2015, …). **Causality – high;** the spatial pattern and temporal trend of increasing concentrations in the 'after' period is plausibly attributed to activities at the mine.	Water quality constituents without effects-based CCME thresholds were not incorporated in the magnitude ratings for assigning effects in the FEIS; however, following the intent of the FEIS magnitude ratings, constituents exceeding baseline but below concentrations associated with adverse effects were considered consistent with a "low" magnitude rating.
	Nutrients	No trigger exceedance (i.e., concentrations = baseline)	Nutrient concentrations are similar to baseline as evidenced by no trigger exceedances in 2018.	Low (i.e., < CCME water quality guidelines) Recent temporal water quality analysis for stations in Third Portage Lake (TPE and TPN), Second Portage Lake, and Wally Lake indicates the results conform with the low effect rating predicted in the FEIS. This conclusion is corroborated by the phytoplankton and benthos community results, which shows relatively diverse, abundant, and stable communities at the NF areas relative to baseline / reference conditions.
	Metals (total and dissolved)	No trigger exceedance (i.e., concentrations = baseline)	Metals concentrations (total and dissolved) were consistently low or below their respective MDLs at the NF, MF, and FF locations in 2018.	
Phytoplankton Section 4.4	Chlorophyll-a	This no trigger for chlorophyll-a for the CREMP.	Concentrations in the reference area samples typically range between 0.2 and 0.7 µg/L in summer months, reflecting the oligotrophic, nutrient poor condition of these lakes; a trend that has not changed over time.	No predictions in the FEIS

Monitoring Component (and report section)	Variable	Summary	Temporal and Spatial Trend Assessment[1, 2]	Annual CREMP Results Compared to FEIS Predictions (Cumberland, 2005)
Phytoplankton	Total Biomass	Increases in phytoplankton biomass were detected at NF areas in 2018 relative to baseline/reference conditions. The magnitude of the increase ranged from 39% to 58% at SP. The only statistically significant change (i.e., increase) was at WAL (p<0.1). There was no discharge to WAL in 2018 and nutrient concentrations (i.e., nitrogen and phosphorus) were similar to baseline (**Section 4.3**).	**Spatial scale – widespread**; phytoplankton biomass was elevated at all NF areas relative to baseline/reference conditions in 2018. **Temporal trend – stable;** historical biomass for the NF areas (**Figure 4-55**) do not show obvious visual signs of temporal increases for individual NF study areas. **Causality – low** SP was the only NF area that received effluent discharge in 2018. The magnitude of the change in biomass at the other NF areas suggests the observed pattern of increase in phytoplankton biomass is likely annual variability in the community rather than mine-related.	The absolute biomass values at the NF are in line with their historical values. Taking into consideration all the lines of evidence (BACI and absolute values plotted over time), there is no evidence to suggest mining operations are increasing primary productivity in the NF areas.
	Taxa Richness	A statistically significant increase (29%; p=0.03) in taxa richness was noted at TPN in 2018 relative to baseline/reference conditions, and the effect size was above the 20% trigger level (**Table 4-6**).	**Spatial scale – localized**; increased taxa richness relative to reference/baseline conditions was only evident at TPN. **Temporal trend – sporadic**; richness has remained stable during the 'after' period. The apparent increases richness at TPN in 2018 relative to baseline/reference conditions is likely an artefact of natural fluctuation in the community composition rather than a decrease. **Causality – low**; the 'apparent' increase in richness at TPN is not plausibly attributable to any site-related activities.	Taxa richness for the phytoplankton communities has been stable throughout the 'after' period (i.e., no apparent loss of community diversity).
Sediment Chemistry Section 4.5	Metals	Targeted coring was completed at TPE and WAL in 2018 to verify increasing concentrations of arsenic at WAL and chromium at TPE in the 2017 CREMP. Sediment toxicity tests were also conducted to assess the bioavailability of sediment metal to 2 benthic invertebrate species (*Chironomus dilutus* and *Hyalella azteca*). Core chemistry results from WAL and TPE were compared to site-specific triggers/thresholds. Parameters with mean concentrations exceeding the trigger value are formally tested using a before-after (BA) statistical model to assess whether concentrations are increasing over time.: **TPE -** Chromium concentrations continue to exceed the trigger in core samples collected in 2018. - slight reduction in *C. dilutus* growth relative to reference.- effects to *H. azteca* survival compared to reference. **WAL -** Arsenic concentrations in core samples collected in 2018 exceeded the trigger value.- No effects to survival or growth in the sediment toxicity tests.	**Spatial scale – localized**; temporal increases in chromium are limited to TPE. Other areas (SP and TPN) are not showing similar trends of increasing chromium in sediment. Slight increases in arsenic at WAL are confined to WAL. **Temporal trend– stable for TPE and WAL** **TPE** – Chromium concentrations at TPE consistently trended higher between the onset of the mine development in TPE in 2009 (i.e., change in status from "before" to "after") and 2013 (**Figure 4-63**), The pattern since 2013 has been variable. Chromium concentrations were lower in 2018 (150 mg/kg) compared to 2017 (200 mg/kg), demonstrating that concentrations are not likely increasing year-over-year. **WAL –** Mean arsenic concentrations in 2018 (46.6 mg/kg) was substantially lower relative to 2017 (62 mg/kg). No evidence to suggest arsenic concentrations are increasing year-over-year, but current concentrations are ~50% higher relative to baseline coring results (before 2013). **Causality – high (TPE; low (WAL);** increasing concentrations of chromium in sediment at TPE were likely related to use of ultramafic rock for dike construction. At WAL, the highly-variable arsenic concentrations in 2018 and 2017 are likely partly related to natural heterogeneity in sediment metals concentrations.	The FEIS noted that release of effluent (i.e., settling of TSS and altered sediment chemistry) "may impact benthos". TPE was the focus of the effects assessment to determine if sediment metals concentrations were "impacting benthos". Key lines of evidence in the weight of evidence assessment were (in order from highest to lowest weighting): 1) **benthos community** - stable or improving results for total abundance and taxa richness over the last six years that were consistent with the baseline range (see below). 2) **toxicity tests** - low bioavailability of sediment metals for *C. dilutus.* Effects to survival were noted for the more sensitive amphipod species *H. azteca,* but these results were given a lower weighting because amphipods are not a taxa group reflected in the benthos communities at reference or NF study area lakes. 3) **chemistry** - Chromium concentrations at TPE, while exceeding the trigger, appear to have stabilized relative to the recent increasing temporal trend. Concentrations of chromium have increased relative to the baseline period, but bulk sediment chemistry is not a good predictor of effects to benthos (see **Figure 4-63** showing similar chromium concentrations at reference are PDL compared to TPE).
	Organics (PAHs)	Sediment hydrocarbon concentrations were below detection for all NF area grab samples in 2018.	Hydrocarbons are not contaminants of potential concern for the CREMP based on recent and historical results. There have been no instances of measured concentrations attributable to site-related activities during the monitoring period.	

Monitoring Component (and report section)	Variable	Summary	Temporal and Spatial Trend Assessment[1, 2]	Annual CREMP Results Compared to FEIS Predictions (Cumberland, 2005)
Benthos Section 4.6	Total Abundance	Benthic invertebrate communities at the NF areas were monitored in 2018. Decreased abundance at TPE relative to INUG in the past four years relative to reference/baseline conditions. Statistically significant differences were noted for the 3 after period (2016-2018) and 4 year after period (2015-2018). The differences are primarily driven by increased abundance at INUG during the monitoring program while abundance at TPE has been relatively stable and consistent with baseline sampling results.	**Spatial scale – localized**; lower abundance (based on the BACI analysis) observed only at TPE. **Temporal trend – stable**; abundance (absolute values) at TPE show stable or improving results over the last six years and consistent with the range observed in baseline. Absolute total abundance at TPE in 2018 (~2,500 organisms/m^2) was stable relative to the range of values dating back to 2012 (2,220 to 3,100 organisms/m^2) and was well within its baseline range. **Causality – low**; the 'apparent' reduction in abundance at TPE in the BACI analysis is partly an artefact of slightly increasing abundance at the reference area INUG while TPE has remained stable during the operation phase. Sediment toxicity testing in 2018 (see above) showed minor reduction in growth for *C. dilutus* (ecologically-relevant), but chromium concentrations in sediment were not correlated with reduced chironomid growth (see **Section 4.6.3**).	As mentioned above, the FEIS predicted altered sediment chemistry "may impact benthos". The identification of potential mine-related impacts generally involves visually examining the data for spatial/temporal patterns that matched mine-related events. An apparent reduction in total abundance was identified in the BACI analyses at TPE in 2018 but the results were considered a BACI "artefact" as abundance has been consistently trending within the baseline range (**Figure 4-68**).
	Total Richness	No changes observed in taxa richness in 2018 at the NF areas compared to reference/baseline conditions.	Richness continues to track higher for most stations. The benthic communities are dominated by chironomids, and the relative proportion of major taxa remains stable at all stations.	

Table ES-2. Summary of key findings from the 2018 Whale Tail CREMP.

Notes

1. 2018 is a transition year for the Whale Tail Project. Whale Tail south basin and Mammoth Lake transitioned from baseline 'before' period to the 'after' period with the onset of dike construction activities in proximity to each lake. Formal temporal trend assessment was not warranted in 2018 with the limited amount of 'after' data. Future CREMP reporting will include formal spatial and temporal trend assessment and comparisons of the annual monitoring results against predictions made in the FEIS (Golder, 2016).

Monitoring Component (and report section)	**Variable**	**Summary**	**Temporal and Spatial Trend Assessment**[1]	**Annual CREMP Results Compared to FEIS Predictions** (Golder, 2016)
Limnology Section 5.2	Oxygen and Temperature	The limnology profiles collected in 2018 show dissolved oxygen and temperature readings are consistent with range of conditions observed in previous monitoring cycles (2015 to 2017).	See the Summary text (over)	Not applicable
	Conductivity	Specific conductivity measurements were low and within the range of normal conditions defined as < 75 µS/cm for measurements collected from the NF, MF, and FF study areas in 2018. **WTS** – The onset of dike construction in Whale Tail Lake did not result in changes in specific conductivity at WTS. Profiles taken at WTS in July and August were virtually identical, measuring 35 µS/cm and 38 µS/cm in August and September **MAM** – There was some evidence of seasonal changes in water quality at MAM based on the late-season conductivity profile data collected in November and December compared to the other sampling events.	**Spatial scale – localized**; increasing conductivity readings were isolated to the NE corner of MAM in November and December (100-175 µS/cm). The second profile collected in November at the opposite end of the lake and away from construction activities was similar to baseline (70-80 µS/cm). **Temporal trend – increasing**; two consecutive months of increasing conductivity readings in MAM indicated a temporal change may be occurring. Monitoring in 2019 is scheduled to verify the trend. **Causality – moderate;** the timing of the increase in conductivity matches construction activities near MAM, but ice cover precludes dust or runoff as likely causes. Ongoing monitoring in 2019.	Not applicable
Water Chemistry Section 5.3	TSS	There were some predictable increases in water quality parameters measured in surface water samples from the south basin of Whale Tail coinciding with dike construction. TSS measured 2 mg/L in August.	**Spatial scale – localized**; elevated TSS was limited to WTS; concentrations at MAM were <DL in all 5 sampling events. There was no indication of changes in water quality in 2018 relative to baseline conditions at NEM, A20, or the areas downstream from WTS and MAM (A76 and DS1). **Temporal trend – sporadic;** TSS peaked in August at WTS but by November concentrations were representative of baseline conditions. **Causality – high;** dike construction was responsible for the observed increase, but the mine was in full compliance with TSS monitoring limits in 2018, indicating the silt curtains were effective in maintaining low sedimentation.	Approach – compare water quality data against predictions in the FEIS (Golder, 2016); deferred until the operations phase of the Project, coinciding with effluent release. From Golder (2016): *The Project is not anticipated to have a significant effect to water quality. There are no reasonably foreseeable future developments and cumulative effects are expected to be negligible.*
	Conventional Parameters, Major Cations, and Nutrients	The study lakes are headwater lakes, so there are no significant natural sources of nutrients or sediment introduced to these lakes, save only local runoff that contributes little nutrient enrichment, but sustains these aquatic ecosystems. Based on total phosphorus, the lakes are ultra-oligotrophic (< 0.004 mg/L; CCME, 2004). **WTS** –concentrations of some nutrients and major cations increased with TSS in August, but were trending lower as TSS returned to baseline concentrations in November. **MAM** – hardness, chloride, nitrate, nitrite, and phosphorus were trending higher in 2018.	**Spatial scale – localized**; limited to WTS and MAM in 2018. For some parameters, there is considerable within-lake variability, indicating the lakes were not well mixed in the months after construction started (see November nitrate results in Figure 5-16 as an example of within-area variability at MAM). **Temporal trend – sporadic (WTS); increasing (MAM)**; concentrations measured in WTS were only transiently elevated; by November most parameters had returned to baseline. At MAM, concentrations of some conventional parameters (e.g., hardness) and nutrients (e.g., nitrate and phosphorus) were trending higher in September and November relative to baseline conditions. **Causality – high;** construction activities are the likely cause of the observed increase in concentration in the latter half of 2018. Follow-up monitoring is planned for 2019.	

Monitoring Component (and report section)	**Variable**	**Summary**	**Temporal and Spatial Trend Assessment**[1]	**Annual CREMP Results Compared to FEIS Predictions** (Golder, 2016)
Water Chemistry Section 5.3	Metals (total and dissolved)	Reported results from 2018 shown good water quality at all six lakes in 2018 in spite of major in-water construction activities in Whale Tail Lake. No exceedances of the CCME water quality guidelines were reported for metals in WTS or MAM. There were increases in some metal relative to baseline conditions in 2018: **WTS** – Parameters that were elevated due to higher TSS (2 mg/L) in August were total (unfiltered) aluminum iron, chromium and to a lesser magnitude arsenic, copper, and lead. **MAM** – Metals such as aluminum, chromium, lead, and zinc were trending higher in the November sampling event compared to baseline conditions in 2014 through 2017.	Spatial and temporal trends described above for WTS and MAM conventional parameters and nutrients broadly applies to metals in two lakes. Monitoring is scheduled at the NF, MF, and FF in 2019 to monitor spatial and temporal trends in metals concentrations among the study areas.	See above
Phytoplankton Section 5.4	Chlorophyll-a	Chlorophyll-a concentrations were typically less than 1 µg/L. indicative of oligotrophic systems (Kasprzak et al. 2008) and representative of baseline trophic status in the various lakes.	The limited data set for the 'after' period at WTS (August, September and November) and MAM (November) meant there was limited value in formally assessing (i.e., statistical BACI analyses) potential changes in biomass and species richness this year. Key points are: - The 2018 phytoplankton community metrics are representative of conditions measured in the baseline period. - Phytoplankton sampling is scheduled at the NF, MF, and FF in 2019 to monitor spatial and temporal trends in primary productivity and community composition.	Approach - assess the potential for changes in lake productivity due to increased concentrations of nutrients in effluent discharged to MAM. Comparisons are limited to the operations phase, coinciding with effluent release. From Golder (2016): *The effect of increased nutrient concentrations to Mammoth Lake, and downstream lakes during operations and closure may result in a general increase in productivity at lower trophic levels. Biomass of phytoplankton, zooplankton, and benthic invertebrates will likely increase during this period.*
	Total Biomass	Total biomass was highest for the July 8th sampling event with ~400 mg/m^3 at measured in WTS and ~350 mg/m^3 and MAM. These data are at the upper end of the range reported in the 2015 to 2017 baseline data.		
	Taxa Richness	The pattern of seasonal variability in species richness observed in 2018 at WTS and MAM was similar to the baseline period. At WTS, the richness in August and September ranged from 27 to 31. By comparison, the 2017 results for August were 33 and 34 taxa.		
Sediment Chemistry Section 5.5	Metals	Sediment grab sampling was completed for metals and analysis and supporting habitat variables in 2018. Sampling was also completed at MAM and WTN (north basin of Whale Tail) for laboratory sediment toxicity tests with *C. dilutus* and *H. azteca* to characterize baseline conditions (i.e., survival and growth) prior to development and potential increases in sediment metals. MAM and WTN vary widely in concentrations of arsenic, providing an opportunity to assess organism responses to different concentrations. Lakes within the Whale Tail study area enriched in some metals compared to CCME sediment quality guidelines (SQGs). Arsenic, cadmium, chromium, copper, and zinc exceeded the interim sediment quality guideline (ISQG) in at least one sample collected in 2018.	Formal statistical analysis of changes in sediment chemistry are done on a 3-year cycle in years when sediment coring (and EEM) is completed. Baseline coring data were collected in 2017 and the first cycle of before-after (BA) statistical analysis is scheduled for the 2020 CREMP. Some key points regarding sediment chemistry at Whale Tail are: - Arsenic is particularly enriched in sediments throughout the study area. Concentrations measured in 2018 exceeded the ISQG in 100% of samples and exceeded the PEL in 25/30 samples. Chromium is also naturally elevated throughout the study area. - There is considerable within-area variability in sediment metals concentrations reported on an annual basis. - No effect on *C. dilutus* and *H. azteca* survival or growth in MAM and WTN relative to lab or field controls (INUG and PDL sediments). Arsenic concentrations in sediment from WTN were > 40-fold higher than the sediment quality guidelines (CCME) with no observed effect.	No prediction for changes in sediment chemistry in the FEIS. From Golder (2016): *- Sediment quality is not considered a valued component (VC) because changes to sediment quality will be managed by minimizing changes to water quality and best management practices to minimize erosion and sedimentation* *- Sediment is not a VC in the FEIS for Meadowbank (Cumberland, 2005)*
	Organics (PAHs)	Hydrocarbon concentrations were less than the detection limits for all analytes measured in the composite samples from 2018.	PAHs, LEPHs, and HEPHs are not considered contaminants of potential concern; annual monitoring is completed as per the study design.	Not applicable

Monitoring Component (and report section)	Variable	Summary	Temporal and Spatial Trend Assessment[1]	Annual CREMP Results Compared to FEIS Predictions (Golder, 2016)
Benthos Section 5.6	Total Abundance	Benthic invertebrate communities at the NF, MF, and FF areas were monitored in 2018. Representative baseline benthos data is available at NF areas (WTS, MAM, and NEM) since 2015. MF and FF sampling at A20, A76, and DS1 was implemented in 2016. Insects are the dominant taxa group in terms of abundance at the Whale Tail study area lakes.	The timing of 2018 sampling (August) relative to timing and extent of dike construction (late July) meant WTS transitioned from the 'before' period to the 'after' period in 2018. The other NF, MF, and FF areas remained in 'before' or baseline status in 2018. Formal BACI analysis of the benthos data was deferred until 2019 because of the short window of time between the onset of construction and the timing of the benthos sampling in mid-August. Plots of the key metrics (i.e., abundance and richness) were used to assess spatial and temporal trends for the Whale Tail study area lakes (**Figure 5 51** to **Figure 5 56**). Key observations about the benthos community are: - The normal range in mean total abundance across years among the 6 study areas is roughly 2,000 to 5,000 organisms/m^2. - Total benthos abundance is highly variable within the lakes and among years. For example, estimated total abundance in two replicates from A76 in 2017 were 14,000 and 24,000 organisms/m^2 compared to approximately 3,000 organisms/m^2 in the other three replicates. - Taxa richness was less variable within and among areas on an annual and inter-annual basis (**Figure 5 54**). - Taxa richness at WTS was highest in 2018 (13 to 20 taxa) compared to richness measured during the baseline period.	Approach – see above for phytoplankton.
	Total Richness	Insects are the dominant taxa group in terms of richness Molluscs are the next most dominant taxa group in terms of the number species, particularly when the abundance of insects and other taxa groups are low (Azimuth 2018a).		

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACKNOWLEDGEMENTS

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ACRONYMS

AEMP	Aquatic Effects Monitoring Program
ANOVA	Analysis of variance
AWAR	All weather access road
BACI	Before/after control/impact
BACIP	Before/after control/impact Paired
BAP	Baker Lake – Akilahaarjuk Point
BBD	Baker Lake – barge dock
BES	Baker Lake – east shore
BPJ	Baker Lake – proposed jetty
CCME	Canadian Council of Ministers of the Environment
COC	Chain of custody
CREMP	Core Receiving Environment Monitoring Program
CRM	Certified reference material
DFO	Department of Fisheries and Oceans
DI	Deionized blank
DOC	Dissolved organic carbon
DQO	Data quality objective
EAS	Effects assessment strategy
EEM	Environmental effects monitoring
EB	Equipment blank
EIA	Environmental impact assessment
FEIS	Final Environmental Impact Statement
FF	Far-field
GPS	Global positioning system
HEPH	Heavy extractable petroleum hydrocarbons
ICP-MS	Inductively coupled plasma mass spectrometry
INUG	Inuggugayualik Lake
ISQG	Interim sediment Quality Guidelines
LCS	Laboratory control sample
LEPH	Light Extractable Petroleum Hydrocarbons
MAM	Mammoth Lake
MDL	Method detection limit
MDMER	Metal and Diamond Mining Effluent Regulations

NEM	Nemo Lake
MF	Mid-field area
NF	Near-field
NWB	Nunavut Water Board
PAG	Potentially acid Generating
PAHs	Polycyclic aromatic hydrocarbons
PDL	Pipedream Lake
PEL	Probable effect level
QA/QC	Quality assurance / quality control
REF	Reference
RPD	Relative percent difference
SEP	Sequential extraction procedure
SOP	Standard operating procedure
SQG	Sediment quality guidelines
SP	Second Portage Lake
TDS	Total dissolved solids
TE	Tehek Lake
TEFF	Tehek Lake Far-field
TIA	Tailings impoundment area
TKN	Total Kjeldahl nitrogen
TOC	Total organic carbon
TSF	Tailings Storage Facility (North and South Cells)
TSS	Total suspended solids
TPE, TPN, TPS	Third Portage Lake sampling areas
UTM	Universal Transverse Mercator
WAL	Wally Lake
WOE	Weight of evidence
WQG	Water quality guideline
WRSF	Waste rock storage facility
WTN, WTS	Whale Tail Lake – North and South Basins

1. INTRODUCTION

1.1. Development of the Aquatic Monitoring Program

Agnico Eagle Mines Ltd.'s (Agnico Eagle) Meadowbank Mine is situated approximately 75 km north of the hamlet of Baker Lake, Nunavut. The aquatic monitoring program has evolved since its inception in 2005; terms and acronyms used to describe the aquatic monitoring programs for the Meadowbank Mine are described below:

- **AEMP** was first used in the 2005 report (*Aquatic Effects Management Program*[1]; Azimuth, 2005a). The AEMP was developed to address issues identified during the Environmental Impact Assessment (EIA) process that could potentially impact the aquatic receiving environments surrounding the development. The scope of the original AEMP described the rationale, framework, strategy, methods, and scope of receiving environment monitoring for the Meadowbank Mine. Receiving environment monitoring conducted in 2006 and 2007 use the term "AEMP" in the annual report titles[2].

  Agnico Eagle has several monitoring programs (e.g., effluent monitoring, ground water monitoring, air quality monitoring) relevant to tracking potential changes to the aquatic receiving environment surrounding the Meadowbank Mine. A restructuring of the AEMP was completed in 2012 (Azimuth, 2012c) to broaden the scope of the AEMP to serves as the overarching 'umbrella' strategy that provides an opportunity to integrate results of individual, but related, monitoring programs (e.g., construction, groundwater, water quality and flow, air quality) in accordance with the original NWB Type A water license requirements. On an annual basis, the restructured AEMP brings in the results of the individual monitoring programs, assesses them using a site-specific conceptual model framework and recommends specific management actions to address potential issues.

  Previously, the term "AEMP" was essentially synonymous with receiving environment monitoring. Given the AEMP's broadened scope, more specific terminology (i.e., CREMP; see below for more details) was developed when referring to aquatic receiving environment monitoring for the Meadowbank mine.

[1] The 2005 AEMP refers to the original AEMP document that served as the blueprint for the CREMP until the CREMP Design Document 2012 (Azimuth, 2012d) was completed.

[2] The Nunavut Water Board Type A License, issued in 2008 and renewed in 2015, defines the "AEMP" as the *Aquatic Effects Monitoring Program*; annual receiving environment monitoring reports since 2008 reflect this subtle change.

- **CREMP** is the acronym for *Core Receiving Environment Monitoring Program*. This term, which is synonymous with "core monitoring program", was first used for the 2009 annual report. It encompasses the core receiving environment monitoring program dating back to 2006. The study design for the CREMP was completed in 2012 (*Core Receiving Environment Monitoring Program (CREMP): Design Document 2012*; Azimuth, 2012d). The 2012 design document reviewed all historic monitoring CREMP data, presented the trigger/threshold derivation process (see **Section 1.5** for description of triggers/thresholds), determined trigger/threshold values for individual parameters, and established the experimental design to optimize the program. The resulting triggers/thresholds and experimental design changes have been integrated into the CREMP since 2012.

  Details for the CREMP study design were recently updated in the *CREMP: 2015 Plan Update* (Azimuth, 2015b), which now includes an addendum (Azimuth 2018b) that outlines aspects of the CREMP that are unique to the Whale Tail Pit Project (hereafter referred to as Whale Tail).

The 2018 CREMP report documents the methods and results of aquatic receiving environment monitoring activities completed at Meadowbank, Whale Tail, and Baker Lake study areas in 2018. As in previous years, this report integrates historical data to identify changes in limnology or water chemistry parameters, sediment chemistry, phytoplankton biomass and benthic community structure associated with mine-related activities at Meadowbank Mine or in Baker Lake. (since 2006) or in Baker Lake (since 2008). With the onset of in-water construction activities for Whale Tail in August 2018, this study area has been brought into the CREMP; spatial and temporal trends related to construction activities (limited data given the August start of construction) and to natural variability will be assessed by integrating the 2018 data with the baseline data (2014 to 2017; Azimuth 2018a).

1.2. Environmental Setting

1.2.1. Meadowbank and Whale Tail Study Areas

The Meadowbank and Whale Tail Projects are situated in the barren-ground central Arctic region of Nunavut within an area of continuous permafrost known as the Wager Bay Plateau (Campbell et al. 2012). These are headwater, ultra-oligotrophic/oligotrophic (nutrient poor and unproductive) lakes, situated on the watershed boundary that separates two main drainages – the Arctic and Hudson Bay drainages. Only a few hundred meters to the north of Second and Third Portage lakes is the divide between water that flows north to the Arctic Ocean (via the Meadowbank and Back River system) or to Chesterfield Inlet and Hudson Bay (via the Quoich River system). Lakes near the Meadowbank project (i.e., Third Portage, Second Portage, and

Tehek) flow into the Quoich River system, while CREMP reference lakes (Tasirjuaraajuk Lake; aka Pipedream Lake [PDL] and Inuggugayualik [INUG]) and lakes in the vicinity of Whale Tail flow north via the Meadowbank and Back River system (**Figure 1-1**).

The local landscape around Meadowbank and Whale Tail Pit consists of rolling hills and relief with low-growing vegetative cover and poor soil development. Numerous lakes are interspersed among boulder fields, eskers and bedrock outcrops, with indistinct and complex drainages. As is common of headwater lakes, all of the project lakes have small drainage areas relative to the surface area of the lakes themselves. Local inflow from surrounding terrain is the predominant influence on water movement within the system. Small channels connect the project area lakes, although there is little flow between lakes except during freshet and possibly none during winter months. Movement by fish between lakes is also rare, as populations remain quite isolated from one another. The ice-free season on these lakes is short, with ice break-up in late-June to mid-July and ice-up beginning in late September or early October. Maximum ice thickness is often 2 m thick or more by March or April.

The Meadowbank and Whale Tail project lakes support healthy communities of plankton, benthos and fish that are typical of oligotrophic Arctic lakes (Azimuth, 2005b). Biological productivity of the lakes is limited by nutrient availability, cold water and a short growing season.

1.2.2. Baker Lake

Baker Lake receives drainage from three major river systems that drain much of the central Arctic: the Thelon River, the Kazan River, and the Dubawnt River (Hutchinson et al., 2018). Baker Lake is the 5th largest lake in Nunavut with a surface area of approximately 1,900 km^2 and 90 km from the mouth of the Thelon River to the narrows at the eastern end of the lake (Nunami, 2007). Water quality in Baker Lake is indicative of a nutrient poor, low alkalinity, soft water Arctic Lake (Hutchinson et al., 2018). Analysis of surface water for metals analysis indicate dilute concentrations throughout Baker Lake with no reported exceedances of human health or freshwater quality guidelines. Water quality in Baker Lake is strongly influenced by freshwater inputs during freshet; results from the lake-wide survey completed by Hutchinson et al (2018) show only weak spatial and seasonal patterns in water quality with the exception of conductivity.

Specific conductivity measurements collected throughout the monitoring period occasionally detect the influence of the deep marine-water influence in Baker Lake. A report by Johnson (1965) suggested three scenarios to explain saline conditions in Baker Lake: 1) ancient seawater trapped during isostatic rebound following glacial retreat, 2) seawater seeping into Baker Lake near the outlet, and 3) seawater entering Baker Lake driven by tides and storm events. Data generated from a more recent 3-year limnological study in Baker Lake between 2015 and 2017 suggest scenario 3 is the most likely explanation for saline water in Baker Lake. The channel or “sill” separating Baker Lake from marine influence is shallow and strong tidal currents and higher tidal amplitude at Chesterfield Inlet compared to other regions in Hudson Bay could contribute salt water to Baker Lake (Hutchinson et al., 2018). Conductivity readings over 1,000 µS/cm were record at depths between 10 and 20 m at locations further away from the influence of freshwater from the Thelon River (Hutchinson et al (2018). Spring freshet is postulate as a key factor that prevents saline water from accumulating in Baker Lake year-over-year.

1.3. Mine Development and Operation

An overview of the mine development for the Meadowbank and Whale Tail Projects is provided below. A list of within-year site activities and a summary of previous CREMP results dating back to 2008 are provided in **Table 1-1**. In addition, a general description of mining-related activities at Baker Lake is provided for that location.

1.3.1. Meadowbank

The construction phase of the Meadowbank Mine officially started in June 2008, upon receipt of the NWB A Water License (2AM-MEA0815; renewed to 2AM-MEA1525 in 2015 and amended to 2AM-MEA1526 in 2018) for the project. The Fisheries and Oceans Canada (DFO) *Fisheries Act* Authorization (NU-03-0191) for the project was issued on July 30, 2008, thus allowing the start of in-water construction activities. Dike construction at Second Portage (East Dike) and Third Portage Lake (Bay-Goose Dike) between 2008 and 2010 allowed development of the open pit deposits. The mine officially opened on February 27, 2010, marking the start of the operations period. Five deposits were mined in the 10 years since the start of operations: North Portage, South Portage, Bay-Goose, Vault, and Phaser.

1.3.2. Baker Lake

The hamlet of Qamani’tuaq located on the northwest shore of Baker Lake is point of entry for fuel, equipment, goods arriving by barge. Open water access to the hamlet from Chesterfield Inlet on Hudson Bay is limited to approximately 2.5 months from the end of July through to mid-October, depending on annual ice conditions. Goods and fuel typically travel from Quebec, around Labrador, and through Hudson Straight. Cargo and fuel tanker vessels moor in Chesterfield Inlet and shallow draft ships or barges pulled by tugs are used to navigate the channel that connecting Baker Lake with Chesterfield Inlet (Agnico Eagle, 2018). Dry goods are transferred at a floating dock facility to the east of the hamlet (CREMP area BPJ is the closest sampling area). Fuel is transferred from the barges to a 60 million litre capacity tank farm located upgradient from the floating dock. Equipment, goods, and fuel are trucked year-round from the hamlet to Meadowbank via 110 km all-weather access road (AWAR) completed by Agnico Eagle in 2008.

Monitoring at Baker Lake started coincided with the first barge season in 2008. The number of barge trips for fuel and goods dating back to 2008 are shown in **Figure 6-2**.

1.3.3. Whale Tail

The Whale Tail Pit Project (Whale Tail) is situated within the Amaruq property, a 408 km^2 exploration area on Inuit and federal crown land. The Project is located approximately 50 km northwest of the Meadowbank mine and is connected by a 64 km all-weather access road that was completed in 2018. The Project is permitted under a separate NWB licence, 2AM-WTP1826, with ore being trucked to Meadowbank to take advantage of the existing infrastructure (e.g., mill, tailings storage, air strip). The first phase of the Project is a conventional open pit currently being developed at the Whale Tail satellite deposit. Major in-water construction activities started in 2018 with dike construction in Whale Tail Lake, fishout of the isolated north basin of Whale Tail lake, development of two quarries, road construction between the Whale Tail dike and the waste rock storage facility (WRSF) north of Mammoth Lake, and expansion of the camp infrastructure.

1.4. CREMP Objectives

The CREMP focuses on identifying changes in limnological parameters, water and sediment chemistry, and in primary (phytoplankton) and secondary (benthic invertebrate community) aquatic producers that may be associated with mine development activities. This is accomplished through the application of a temporal/spatial trend assessment that includes application of quantitative decision criteria (i.e., early warning “triggers” and action “thresholds”) to facilitate immediate and objective decision-making regarding appropriate management actions. This information is integrated annually into the Aquatic Ecosystem Monitoring Program (AEMP) for holistic environmental management and decision making.

The 2005 AEMP framework (Azimuth, 2005a) presented a receiving environment monitoring strategy consisting of two components:

Core Receiving Environment Monitoring Program – was designed based on our understanding of mine construction, operation and infrastructure (e.g., dikes, effluents, stream crossings, roads, etc.) and has been developed to detect mine-related effects at temporal and spatial scales that are ecologically relevant. The program was expanded to include Baker Lake in 2008 and Whale Tail in 2018. The program was updated based on the recommendations of the *CREMP: Design Document 2012* (Azimuth, 2012d) and more recently, described in detail in the *CREMP: 2015 Plan Update* (Azimuth, 2015b) and Whale Tail Pit Addendum (Azimuth 2018b). The study design is based on a before-after-control-impact (BACI) approach, but has also incorporated the concept of gradients in exposure. (e.g., by incorporating near-field, mid-field and far-field areas in addition to reference areas).

Targeted Studies – targeted studies are designed to address specific questions related to mine development during construction or operation and typically have narrower temporal or spatial bounds. These results are integrated with and complementary to the routine CREMP. Examples include dike construction monitoring (e.g., Azimuth, 2009a) and the total suspended solids (TSS) effects assessment studies (EAS) (e.g., Azimuth, 2009b). Recently, targeted studies have been carried out to determine the toxicity and bioavailability of metals in sediments at TPE (Azimuth, 2016; this report).

1.5. CREMP Strategy

CREMP reporting for the Meadowbank and Baker Lake study areas changed substantially starting in 2011 with a stronger focus on assessing potential temporal and spatial trends in the data related to mining activity. Greater emphasis is now placed on identifying changes to support the AEMP (**Section 1.1**) and ultimately the environmental management process, rather than on providing a detailed description of the annual results in isolation. To that end, this CREMP report applies numerical decision criteria (i.e., triggers and thresholds) to assess the magnitude of change in CREMP monitoring variables (e.g., water quality, sediment chemistry, lower trophic level communities [i.e., phytoplankton and benthos]). The same approach of using will be applied at the Whale Tail study area in 2019 with the Project transitioning from the baseline 'before' period to the 'after' period.

The 2012 AEMP (Azimuth, 2012c) described a two-tiered approach (**Figure 2-2**) for evaluating changes in the monitoring components (e.g., water quality, benthos community) based on 'trigger' and 'threshold' level changes:

- **Trigger values** are typically lower or more conservative than threshold values. They serve are early warning criteria that might lead to action. Exceedance of a trigger value does not necessarily imply that an adverse effect may be expected. The triggers may be based on absolute numbers (e.g., an increase half-way from baseline to an identified effect threshold) or statistical criteria (e.g., statistically significant trend that predicts exceedances of a threshold within 3 years).

- **Thresholds** are legal requirements, regulatory guidelines (e.g., CCME), or other discrete benchmarks, below which unacceptable adverse effects are not expected and above which adverse effects may occur. If effects-based thresholds do not exist or are not warranted for a variable, then early warning triggers will be developed without thresholds. In such cases, if triggers are exceeded then the implications of such exceedances can only be understood through the integration of results from other AEMP monitoring programs, or, if important information gaps still exist, through focused studies (e.g., risk assessment).

Comparison of the data to trigger values is the initial analytical focus. If trigger values are exceeded, the data are then compared to the applicable thresholds. (if available[3]). Details regarding the derivation of trigger and threshold values for the CREMP are presented in the *CREMP: Design Document 2012* (Azimuth, 2012d).

The application of trigger and threshold values complements the spatial-temporal trends assessment initiated in the 2011 CREMP (Azimuth, 2012a), which used trend plots (each showing monitoring results since 2006) to identify patterns of change consistent with one or more of the mining activities described in **Section 1.3**.

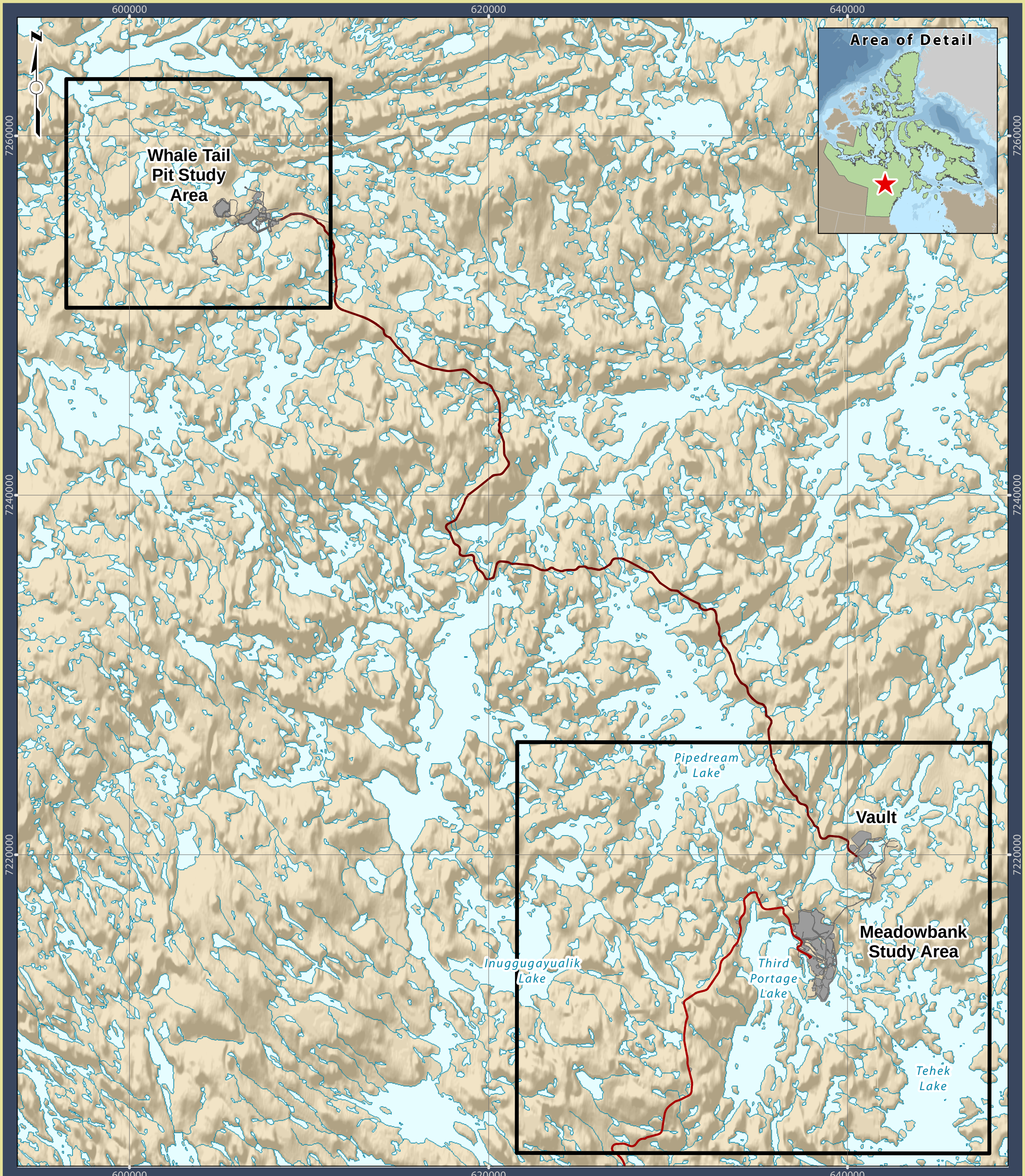
The general rationale for conducting the trend assessment followed these principles:

- **Establish Expected Conditions** – Control data (i.e., combination of baseline [i.e., pre-mining] data from impact areas and data from remote reference or control areas; see **Table 2-4**) were examined to set expectations for a parameter (e.g., water or sediment metal concentration, etc.) in the absence of mining activity. Baseline data were used to infer relative spatial differences (e.g., between a NF and Ref area) and reference data were used to infer regional temporal changes (e.g., the regional decrease in benthic community abundance between 2009 and 2010).
- **Compare Patterns of Change** – With expected conditions in mind, impact data (i.e., data collected at NF and MF areas after the onset of mining-related activity in proximity to an area; see **Table 1-1**) were assessed visually for spatial-temporal patterns (e.g., short-term [in any year] spikes [rapid rises that return to baseline] or longer-term trends [gradual or rapid increases that persist]) matching mining activity (e.g., rise in TSS concentrations at SP in August 2008). Where observed, the spatial and temporal extent and magnitude of the

[3] For waster and sediment quality, thresholds were generally set to existing environmental quality guidelines. Thresholds were not derived in cases where guidelines were unavailable or when baseline concentrations naturally exceeded existing guidelines (e.g., some metals in sediment).

changes were characterized (i.e., do they extend to MF or FF areas, and if so, at what magnitude/duration?).

- **Provide Context for Magnitude of Change** – As discussed above, site-specific triggers and thresholds were used to provide some context for observed changes to CREMP monitoring parameters. In addition, where applicable and available, results of target studies (e.g., TSS EAS studies) were used to help interpret changes in biological parameters and endpoints.
- **Identify Parameters for Management** – Identify parameters requiring management action on one of two levels: continued trend monitoring (i.e., to follow low magnitude or weak trends), or active follow-up with more detailed quantitative assessment (i.e., a targeted study to address a potential concern). This process will emphasize issues or concerns present in this year's CREMP results.



Legend

- Mine Sites
- All-Weather Access Road
- Whale Tail Haul Road
- River
- Lake

0 2 4 6 8

Kilometres

Projection: UTM Zone 14 NAD83

Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.

Figure 1-1. Meadowbank – Whale Tail Pit Expansion Project Study Area Overview

Meadowbank Gold Project

Prepared for: AGNICO EAGLE

By: CASLYS CONSULTING

February 2019

Table 1-1. Chronology of mine development, operational activities, and receiving environment findings (2008 – 2018).

Notes
1. The summary provided here pertains to Meadowbank study areas (2008 – 2018). Whale Tail study areas were integrated into the summary of findings in 2018. Baker Lake is not considered a receiving environment for the CREMP (annual results are not summarized in this table).

Year	Major Mine-Related Activities	Receiving Environment Overview[1]
2008	● Major in-water construction activities included the East Dike (located in Second Portage Lake) and the Western Channel Dike (located between Third Portage Lake and Second Portage Lake); the closest CREMP sampling area to these activities was the Second Portage Lake area (SP). ● Other site-related activities included rock crushing, road building, pit blasting, ground preparation, and infrastructure construction. ● Barge traffic increases in Baker Lake to support construction.	● As described in detail elsewhere (Azimuth, 2009a; 2009b), East Dike construction led to a sedimentation event that extended through Second Portage Lake (SP) to Tehek Lake (TE). The potential impact of construction-related sediment releases to the aquatic environment was the focus of the four-year EAS study (Azimuth, 2009b, 2010d, 2011a, 2012c).
2009	● Dewatering discharges (i.e., impounded Second Portage Lake water with TSS) were directed primarily into the north basin of Third Portage Lake (TPN), but also into Second Portage Lake (March to July and Oct to Dec, 2009). ● Bay-Goose Dike construction started in late July 2009. ● Most of the site preparation and road infrastructure was completed in 2009. ● North Portage Pit was the primary focus of blasting and mine operations. ● Barge traffic increases in Baker Lake.	● Despite a number of precautions, storm winds broke the Bay-Goose Dike turbidity barrier containment system, leading to another sedimentation event in late August. ● Elevated TSS (and other parameters) was primarily restricted to east basin of Third Portage Lake (TPE) and to a minor extent into SP and TE. The implications of the release were assessed in the EAS study (see above).
2010	● Bay-Goose Dike construction completed using additional mitigation measures. ● Mine officially opened on 27 Feb 2010, marking the start of the operations period. ● Pit development focused on North Portage and South Portage pits. ● Waste rock to rock storage facility (RSF). Tailings to impoundment area (TIA). Contact water from operations not discharged to receiving environment. ● Dewatering of SP impoundment to TPN continued, with discharge now subject to MMER. ● Barge traffic increases in Baker Lake.	● Bay-Goose Dike construction leads to less-pronounced sedimentation event in TPE and extends through SP to TE; EAS studies continue. ● TPN (dewatering) TSS concentrations generally consistent with baseline conditions.
2011	● Mining operations focus on North Portage and South Portage pits. ● Waste rock to rock storage facility (RSF). Tailings to impoundment area (TIA). ● Construction activities limited to mine footprint. ● Dewatering of SP and TPE to TPN continued, with treatment added to reduce fine sediment and turbidity. ● Barge traffic stabilizes in Baker Lake.	● TPN focus of routine EEM study - no mine-related effects detected (Azimuth, 2012e). ● TPN TSS concentrations consistent with baseline. ● The TSS EAS targeting dike construction sedimentation events completed.
2012	● SP and TPE dewatering discharges to TPN finished by spring. Diffuser installed and effluent (mix of residual Bay-Goose water, contact water, East Dike seepage and run-off) discharge to TPN commences; treatment (for fine sediment, turbidity) continues. ● North cell non-contact water diversion ditches completed in August (intercepting run-off prior to the tailings and waste rock areas and diverting to NP2 and Dogleg ponds). ● Vault access road constructed and site preparation activities for the Vault Pit and Vault Dike commence. ● Barge traffic remains stable in Baker Lake; 200-L diesel spill occurs, but cleaned up successfully.	● TPN TSS concentrations generally consistent with baseline. ● Minor mine-related trends identified for a number of water chemistry parameters at near-field areas: conductivity, sulphate and total dissolved solids. ● Spill-related monitoring show no traces of hydrocarbons in Baker Lake.
2013	● Effluent discharge to TPN continued. ● Fishout activity in Vault lake was completed. ● Vault lake was dewatered into Wally Lake (ongoing) and did not require TSS treatment. ● Minor construction modifications to north cell diversion ditches completed. ● Completion of the Airstrip extension (18m) into Third Portage Lake in March. ● Seepage from Rock Storage Facility (ST-16) through the road into NP2 identified (additional monitoring in NP2 to evaluate near-shore water quality).	● TPN TSS concentrations consistent with baseline. ● Minor mine-related trends identified for a number of water chemistry parameters at near-field areas: alkalinity, conductivity, calcium and total dissolved solids. ● TPE sediment chromium concentrations were elevated above trigger value; better spatial coverage needed to reduce uncertainty in 2014.

Year	Major Mine-Related Activities	Receiving Environment Overview[1]
2014	● Effluent discharge to TPN from the Portage Attenuation Pond occurred only from June 10 to July 5. Discharge to TPN is now complete. The former Portage Attenuation Pond has now become the South Cell for tailings deposition. ● EEM Cycle 2 Study Design was conducted at the end of August through the beginning of September (no TPN discharge at this time). ● Vault Dewatering into Wally Lake from June 20 to 29 (now complete); discharge from Vault Attenuation Pond into Wally Lake from July 24 to August 14. No TSS treatment for Vault Discharge. ● New discharge into Second Portage Lake during all of 2014 (except from May 3 to July 28): two seepage collection points (North and South) are situated on west side of the East Dike to collect seepage through dike from SP. Water is pumped from both collection points, which are connected together before discharging back into Second Portage Lake through a diffuser. No TSS treatment for East Dike Discharge. ● No seepage water from Rock Storage Facility (ST-16) reaching the NP2 Lake in 2014. ● Commercial mining in Vault Pit started at the beginning of 2014. No major construction or modifications in 2014.	● Minor mine-related trends identified for a number of water chemistry parameters at near-field areas: conductivity, hardness, Ca/Mg/K/Na and total dissolved solids. ● Temporal trend in TPE sediment chromium confirmed in coring study; targeted study recommended for 2015.
2015	● No discharge to TPN in 2015 ● Vault discharge to Wally from July 7th to September 10th. No TSS treatment needed. ● East dike (North-South) discharge to SP all year except from June 16th to August 10th. Discharge was stopped for increasing TSS levels as no treatment is available for this location. The discharge from East Dike that was not directed to 2PL was discharged in the Portage Pit and then pumped to the South Cell TSF (Tailings Storage Facility). ● No seepage water from Rock Storage Facility to NP-2. Monitoring ongoing. ● HCMP work completed for TP, SP and Dogleg lakes and at water crossing R02 along the AWAR. ● One incident of elevated TSS from Vault road culverts to NP-1, early June, during freshet. Barriers installed. No impacts observed to Dogleg Lake.	● Minor mine-related trends identified for a number of water chemistry parameters at near-field areas: conductivity, hardness, Ca/Mg/K/Na and total dissolved solids. Parameters with effects-based thresholds (e.g., CCME water quality criteria) were below their respective trigger values in 2016. ● Targeted sediment bioavailability and toxicity testing was completed at TPE. Toxicity test results on *Chironomus dilutus* and *Hyalella azteca,* combined with sequential extraction tests on the sediment, indicated current chromium concentrations at TPE are unlike to adversely affect the benthic invertebrate community. Continued monitoring was recommended for 2016, but addition target studies were not recommended for 2016. ● Phytoplankton and benthic invertebrate community results for the impact stations were within the range of reference/baseline conditions.
2016	● Vault discharge to Wally from June to September. No TSS treatment needed. ● East dike (North-South) discharge to SP all year. ● No seepage water from Rock Storage Facility to NP-2. Monitoring ongoing. ● Phaser lake dewatering - August 26th to September 10th and September 15th to October 4th ● Phaser Lake fishout from August 13th to 31st and September 10th to 25th ● No Goose Pit reflooding activities ● Pit E and pushback assessment ● Mining focused on Vault Pit and Pit A ● Amaruq exploration road construction (km 25 at end of 2016)	● Minor mine-related trends identified for a number of water chemistry parameters at near-field areas: conductivity, hardness, Ca/Mg/K/Na and total dissolved solids. ● Similar trend of elevated chromium in sediment grab samples from TPE, but the concentrations appear stable relative to those measured in 2015. ● Phytoplankton and benthic invertebrate community results for the impact stations were within the range of reference/baseline conditions.
2017	● Vault discharge to Wally from June to October. No TSS treatment needed ● East dike (North-South) discharge to SP all year except from May 12th to September 5. Discharge was also stopped from September 23 to October 29th. Discharge was stopped for increasing TSS levels as no treatment is available for this location. The discharge from East Dike that was not directed to SP was discharged in the Portage Pit and then pumped to the South Cell TSF (Tailings Storage Facility). ● No seepage water from Rock Storage Facility to NP-2. Monitoring ongoing ● No Goose Pit reflooding activities ● Mining focused on Vault Pit and Pit A, Pit E and Phaser Pit ● Amaruq exploration road completed ● Phaser Pit started in November ● HCMP work completed for TP, SP and Dogleg lakes and at water crossing R02 along the AWAR ● One incident of elevated TSS from Vault road to NP-1, early June, during freshet. Barriers installed. No impacts observed to Dogleg Lake.	● Minor mine-related trends identified for a number of water chemistry parameters at near-field areas: conductivity, hardness, Ca/Mg/K/Na and total dissolved solids. Parameters with effects-based thresholds (e.g., CCME water quality criteria) were below their respective trigger values in 2017. ● Phytoplankton and benthic invertebrate community results for the impact stations were within the range of reference/baseline conditions. ● Core chemistry was analyzed for all study areas in 2017. Chromium in TPE and Arsenic in WAL were flagged for follow-up assessment in 2018 based on BACI results.

Year	Major Mine-Related Activities	Receiving Environment Overview[1]
2018	*Meadowbank* ● East dike (North-South) discharge to SP all year except from June 4th to August 21st. Discharge was stopped for increasing TSS levels as no treatment is available for this location. The discharge from East Dike that was not directed to SP was discharged in the Portage Pit and then pumped to the South Cell TSF (Tailings Storage Facility). ● No seepage water from Rock Storage Facility to NP-2; monitoring ongoing ● No Goose Pit reflooding activities ● Mining focused on Vault Pit and Pit A, Pit E and Phaser Pit ● No discharge to Wally in 2018	● See **Section 4** for a discussion of the 2018 CREMP results for the Meadowbank study area lakes.
	Whale Tail Pit Expansion Project ● Whale Tail Dike Construction began on July 27 ● Whale Tail Pit commencement of Quarry 2 began in September ● Freshwater intake from NEMO Lake started on Oct 28 ● Whale Tail North fishout Aug 13 - Sept 28 ● Newterra Wastewater treatment system at AMQ operational in March ● Crusher activities started on the waste rock storage facility (WRSF) on Oct 21 ● Quarry 2 overburden stripping on . ● Snow removal in preparation of dike construction near Mammoth Lake (WRSF dike and Mammoth Dike)	● 2018 was a transition year for the Whale Tail Pit study area. Only WTS was considered "impact" from August onwards and impacts to water quality, sediments, and biota are considered unlikely for 2018. ● See **Section 5** for a discussion of the 2018 CREMP results for the Whale Tail study area lakes.

2. CREMP STUDY DESIGN

2.1. Overview

The *CREMP: 2015 Plan Update* (Azimuth, 2015b) describes the CREMP study design and methods, and integrates a number of changes from the previous CREMP plan (Azimuth, 2010d), including those stemming from the NWB Type A Water License renewal process. The *Whale Tail Pit Addendum* (Azimuth 2018b) mirrors the CREMP study design in the monitoring components, approach to sampling (SOPs), QA/QC program, and data evaluation[4].

To streamline the annual report and reduce redundancy, aspects of the CREMP study design presented in the *CREMP: 2015 Plan Update* are not repeated herein. Readers looking for detailed information on the aspects of the study design such as sampling methods, QA/QC protocols and procedures, and data evaluation criteria are referred to Azimuth (2015b). A summary of the CREMP study design is included to guide the reader.

2.2. Routine CREMP Sampling

2.2.1. Sampling Areas

The CREMP is intended to detect changes at a basin or lake scale to help define the extent (both spatially and temporally) of any changes in water quality, sediment chemistry, or biological communities (phytoplankton and benthos). A common element for the Meadowbank and Whale Tail Pit study designs is the use of near-field (NF), mid-field (MF), and far-field (FF) areas to provide spatial context when interpreting potential changes year-over-year. Near-field areas provide the first line of early-warning for introductions of stressors into the receiving environment. These areas are situated closest to the development near dikes, dewatering discharge points, and proposed effluent sources. MF and FF areas are located farther downstream from the NF monitoring areas and provide insights into the spatial extent of any observed changes in chemistry or biological communities closer to the source. A detailed description of the Meadowbank and Baker Lake study areas is included in the *CREMP: 2015 Plan Update* (Azimuth, 2015b); the Whale Tail Pit study areas are described in the addendum to the *CREMP: 2015 Plan Update* (Azimuth, 2018b). A brief description of the sampling areas is provided below.

[4] New triggers will be developed for evaluating water and sediment quality for lakes within the Whale Tail study area.

Meadowbank Sampling Areas

There are 9 sampling areas included in the Meadowbank CREMP. Third Portage Lake East Basin and North Basin (TPE and TPN), Second Portage Lake (SP), and Wally Lake (WAL) are the NF areas monitored annually for changes related to operations at the Meadowbank mine and mill. Tehek (TE) the South Basin of Third Portage Lake (TPS) and Tehek far-field (TEFF) are monitored only if changes are detected upstream at the NF locations consistent with the strategy outline in **Section 2.2.3**. Two reference areas are shared for the Meadowbank and Whale Tail Pit programs: Inuggugayualik Lake (INUG) and Tasirjuaraajuk Lake (aka Pipedream Lake [PDL]). INUG has been the core reference area since formal monitoring began in 2006. PDL was added to the Meadowbank CREMP in 2009; while the absence of data at this area from 2006 to 2008 make it of limited utility in the BACI statistical analyses, it provides insights into the strength of regional patterns (i.e., how well it matches INUG).

The 2018 sampling areas for the Meadowbank CREMP are shown in **Figure 4-1** (water and phytoplankton) and **Figure 4-2** (sediment and benthos).

Whale Tail Sampling Areas

There are 6 lakes currently included in the Whale Tail Pit CREMP study design. Whale Tail Lake South Basin (WTS) and Mammoth Lake (MAM) are NF areas designed to detect changes related to dike construction in Whale Tail Lake and Mammoth Lake and eventual discharge of treated water during operations. Nemo Lake (NEM) is also considered a NF area because of its proximity to the site, even though it is situated in a different watershed. MF areas are Lake A20 (upstream from WTS, but will join WTS after flooding) and Lake A76 (downstream from MAM). Lake A76 is situated at the junction of the two flow paths leading to Lake DS1. Given its morphology and location, it represents an ideal MF exposure area for both flow paths. Lake DS1 is the FF location to provide additional context for characterizing spatial extent of effects.

The 2018 sampling areas for the Whale Tail Pit CREMP are shown in **Figure 5-1** (water and phytoplankton) and **Figure 5-2** (sediment and benthos).

Baker Lake Sampling Areas

There are two NF areas for the Baker Lake CREMP, one targeting the hamlet's barge landing area (Baker Barge Dock [BBD]) and the other AEM's fuel storage facility (Baker Proposed Jetty[5] [BPJ]). The primary reference area for Baker Lake is located approximately 10 km kilometers to the east of the hamlet along the north shore of the lake (Baker Akilahaarjuk Point [BAP]). A

[5] Note that while a jetty was initially considered, the idea was abandoned in favour of continued use of the existing barge landing.

second reference area on the East Shore of Baker Lake (BES) between BAP and BPJ was added in 2011 to provide additional context for interpretation of sediment chemistry and benthic invertebrate data.

The 2018 sampling areas for the Baker Lake CREMP are shown in **Figure 6-1**.

2.2.2. Monitoring Components

Water quality, sediment quality, phytoplankton community, and benthic invertebrate community were monitored in the core 2018 program. Sampling was undertaken according to established SOPs included in the *CREMP: 2015 Plan Update* (Azimuth, 2015b). Locations for water, limnology, and phytoplankton were selected randomly for the Meadowbank and Baker lakes areas from within their respective lake basins. The Whale Tail Pit study area lakes are smaller and more variable in depth compared to the Meadowbank project lakes. To avoid selecting locations in less than 5 m of water, a number of fixed water quality monitoring locations were established in each lake. Two locations were randomly selected for monitoring in each event. Sediment for chemistry and benthic invertebrate community analyses were collected from the established areas (i.e., depositional zones between 6.5 m and 9 m) in each basin/lake. 2018 was a supplemental coring year, with follow-up sampling conducted at TPE and WAL.WAL to verify results from the 2017 CREMP (Azimuth, 2018c).

Table 2-1 lists the monitoring components sampled at the various study areas in 2018. Global Positioning System (GPS) Universal Transverse Mercator (UTM) coordinates (in NAD 83) are shown in **Table 2-2** for the Meadowbank lakes and Baker Lake and **Table 2-3** for the Whale Tail Pit study lakes.

Samples from the 2018 CREMP were sent to the laboratories listed below for analysis:

- Water and bulk sediment chemistry – ALS Laboratories (Burnaby, BC)
- Phytoplankton taxonomy – Plankton R Us Inc. (Winnipeg, MB)
- Benthic invertebrate taxonomy – ZEAS Inc. (Nobleton, ON)

2.2.3. Sampling Effort

A results-driven sampling strategy for the Meadowbank study lakes was developed as part of the *CREMP: 2015 Plan Update* (Azimuth, 2015b). The objective of this strategy is to increase the overall efficiency of the CREMP by maintaining monitoring intensity in the areas most likely to be affected by mining-related activities (i.e., NF areas), while potentially reducing monitoring intensity at MF and FF areas depending on the water quality results observed at up-gradient areas. The annual decision framework presented in the *CREMP: 2015 Plan Update* (Azimuth, 2015b; **Figure 2-1** [below]) applies to MF and FF areas at Meadowbank (i.e., MF area TE (which is paired with upstream NF areas TPE, SP, and WAL), MF area TPS (which is paired with NF area TPN), and to FF area TEFF (paired with upstream MF area TE). The same strategy may eventually be implemented at Whale Tail as more years of ‘after’ data become available. For the time being, monitoring at Whale Tail MF and FF areas will continue at the same frequency as the NF areas (i.e., 5 events in 2019).

As per the normal Meadowbank CREMP data analysis process, NF results are evaluated on an annual basis (i.e., with CREMP reporting due at the end of March following each monitoring year), with the NF results (i.e., for “Year”) dictating the monitoring requirements for the MF area in the subsequent year (i.e., “Year +1”). The Year +1 NF and MF results are used as the basis to determine the MF and FF monitoring requirements for Year +2, and so on. While the full CREMP program will be conducted at each NF area each year, the specific monitoring requirements for the MF and FF areas vary based on the NF and MF results, respectively. Below are the various outcomes of the CREMP data analysis and associated program requirements for MF and FF areas in the following year (see Azimuth, 2015b for more details, including a worked example of the strategy):

- No changes identified – no statistical changes above any trigger values. No further sampling required.
- Minor changes identified – statistically significant changes exceeding the early warning trigger values for parameters without effects-based threshold values (i.e., trigger values are based on the 95th percentile of the baseline distribution). Spot sampling through-ice is required to determine if changes extend to MF area (or to FF if such changes are seen at an MF area), but no further sampling is needed that year at the MF or FF areas unless moderate changes (see below) are identified at those areas.
- Moderate changes identified – statistically significant changes exceeding the early warning trigger values for parameters with effects-based thresholds (e.g., CCME water quality guidelines for water chemistry parameters). Full CREMP water sampling (all events) is required to determine if changes extend to MF area (or to FF if such changes are seen at an MF area).
- Major changes identified – statistically significant changes exceeding the effects-based threshold values. Full CREMP program (i.e., including sediment and biological components) is required to determine if changes extend to MF area (or to FF if such changes are seen at an MF area).

Minor changes to water quality parameters without toxicologically-derived effects-based thresholds were identified in the 2017 CREMP (Azimuth, 2017a). Following the strategy outlined above, these results warranted a pared-down monitoring program at MF (TPS and TE) and FF

(TEFF) areas in 2018. Water sampling through-ice was completed (at NF, MF and FF areas) in May 2018, but further water sampling at MF or FF areas during the open-water season was not completed.

Table 2-1. CREMP sampling summary, 2018.

Month	Field Team	Seasonal Conditions	Component	Meadowbank Areas									Baker Areas				Whale Tail Pit Areas					
				INUG	PDL	TPN	SP	TPE	WAL	TPS	TE	TEFF	BAP	BES	BBD	BPJ	WTS	MAM	NEM	A20	A76	DS1
				REF	REF	NF	NF	NF	NF	MF	MF	FF	REF	REF	NF	NF	NF	NF	NF	MF	MF	FF
January	Agnico	Ice	L			✓	✓	✓	✓													
February	Agnico	Ice	L			✓	✓	✓	✓													
March	**No Sampling 2018**																					
April	Agnico	Ice	L			✓	✓	✓	✓													
May	Agnico	Ice	L,W,P	✓	✓	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓	✓	✓
June	***Ice not safe***																					
July	Agnico	Open-water	L,W,P	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓	✓	✓	✓	✓
August	Azimuth	Open-water	L,W,P	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓	✓	✓	✓	✓
			B,S	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
			C					✓	✓													
September	Agnico	Open-water	L,W,P	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓	✓	✓	✓	✓
October	***Ice not safe***																					
November	Agnico	Ice	L,W,P	✓	✓	✓	✓	✓	✓								✓	✓	✓	✓	✓	✓
December	Agnico	Ice	L			✓	✓	✓	✓								✓	✓	✓			

Notes:
Components: L=Limnology; W=Water chemistry; P=Phytoplankton; B=Benthic invertebrates; S=Sediment grab chemistry; C=Sediment coring chemistry.
☑ = monitoring components were collected.
Area designations: C=Control; I=Impact; REF=reference (in grey shading); NF=near-field (in blue shading); MF=mid-field (in pink shading); FF=far-field (in teal shading)
Area IDs:
Meadowbank and Whale Tail Pit Reference areas: INUG = Inuggugayualik Lake; PDL = Pipedream Lake
Meadowbank areas: TPN, TPE, TPS = Third Portage Lake - North, East, South basins; SP = Second Portage Lake; WAL = Wally Lake; TE, TEFF = Tehek Lake (Mid-field and Far-field)
Baker Lake areas: BAP, BES, BBD, BPJ=Baker Lake - Akilahaarjuk Point, East Shore, Barge Dock, Proposed Jetty.
Whale Tail Pit areas: WTS = Whale Tail Lake South Basin; MAM = Mammoth Lake; NEM = Nemo Lake; A20 = Lake A20; A76 = Lake A76; DS1 = Lake DS1

Table 2-2. CREMP sampling coordinates for Meadowbank and Baker Lake study areas, 2018.

Area[1]	Area Type[2]	Area-Replicate	**Water & Phytoplankton** (monthly)				**Benthos & Sediment Grabs** (August)					**Sediment Cores** (August)			
			Month	Depth (m)	Zone & Easting	Northing	Area-Replicate	Sample Type[3]	Depth (m)[4]	Zone & Easting	Northing	Area-Replicate	Depth (m)	Zone & Easting	Northing
TPE	NF	TPE-Limno	January	9.75	14W 639132	7211780	TPE-1	B & C	7.6	14W 639070	7211513	TPE-SC-1	7.8	14W 639074	7211514
		TPE-Limno	February	11.75	14W 639130	7212559	TPE-2	B & C	8.2	14W 639084	7211540	TPE-SC-2	7.7	14W 639065	7211512
		TPE-Limno	April	8.72	14W 638069	7211804	TPE-3	B & C	7.6	14W 639114	7211555	TPE-SC-3	8.2	14W 639088	7211542
		TPE-110	May	11.4	14W 639160	7211237	TPE-4	B & C	9.5	14W 639156	7211692	TPE-SC-4	8.2	14W 639095	7211543
		TPE111	May	14.8	14W 639597	7210501	TPE-5	B & C	6.8	14W 639134	7211718	TPE-SC-5	8.5	14W 639117	7211556
		TPE-112	July	8	14W 639228	7210475	TPE-COMP	C				TPE-SC-6	8.0	14W 639108	7211557
		TPE-113	July	7	14W 638650	7210713						TPE-SC-7	9.5	14W 639153	7211693
		TPE-114	August	7.2	14W 639452	7212190						TPE-SC-8	9.0	14W 639142	7211745
		TPE-115	August	17.5	14W 637889	7211573						TPE-SC-9	8.1	14W 639132	7211757
		TPE-116	September	19	14W 639281	7212470						TPE-SC-10	8.0	14W 639141	7211732
		TPE-117	September	8	14W 638654	7210866									
		TPE-118	November	20	14W 639087	7212252									
		TPE-119	November	11	14W 638776	7211036									
		TPE-Limno	December	5	14W 639317	7211154									
TPN	NF	TPN-Limno	January	7.75	14W 636622	7214618	TPN-1	B & C	7.5	14W 636384	7215540				
		TPN-Limno	February	10.5	14W 635393	7212840	TPN-2	B & C	8.0	14W 636407	7215527				
		TPN-Limno	April	15	14W 637058	7213450	TPN-3	B & C	7.8	14W 636420	7215596				
		TPN-110	May	25	14W 634782	7215555	TPN-4	B & C	8.4	14W 636508	7215448				
		TPN-111	May	25	14W 634780	7214296	TPN-5	B & C	8.6	14W 636585	7215416				
		TPN-112	July	17	14W 636063	7213839	TPN-COMP	C							
		TPN-113	July	7.3	14W 635325	7216063									
		TPN-114	August	28.9	14W 634842	7216050									
		TPN-115	August	10.2	14W 636276	7213580									
		TPN-116	September	10	14W 635652	7214191									
		TPN-117	September	15	14W 635284	7213016									
		TPN-118	November	8	14W 635249	7213098									
		TPN-119	November	19.5	14W 636495	7214244									
		TPN-Limno	December	15.5	14W 636723	7213300									
TPS	MF	TPS-59	May	14.5	14W 635189	7210235									

Area[1]	Area Type[2]	Area-Replicate	Water & Phytoplankton (monthly)				Benthos & Sediment Grabs (August)					Sediment Cores (August)			
			Month	Depth (m)	Zone & Easting	Northing	Area-Replicate	Sample Type[3]	Depth (m)[4]	Zone & Easting	Northing	Area-Replicate	Depth (m)	Zone & Easting	Northing
TPE	MF	TPS-60	May	17	14W 633467	7208427									
SP	NF	SP-Limno	January	16	14W 640481	7213614	SP-1	B & C	8.9	14W 639985	7214057				
		SP-Limno	February	5.5	14W 639987	7213809	SP-2	B & C	7.2	14W 640022	7214105				
		SP-Limno	April	8.3	14W 639597	7214259	SP-3	B & C	7.7	14W 640052	7214143				
		SP-110	May	5.5	14W 640360	7213373	SP-4	B & C	7.1	14W 640059	7214163				
		SP-111	May	11	14W 640094	7214172	SP-5	B & C	7.2	14W 640070	7214184				
		SP-112	July	6.5	14W 640295	7213834	SP-COMP	C							
		SP-113	July	8	14W 640605	7212810									
		SP-114	August	25	14W 640764	7213488									
		SP-115	August	8.6	14W 640175	7214177									
		SP-116	September	12	14W 640102	7214134									
		SP-117	September	12.5	14W 640607	7213107									
		SP-118	November	11	14W 639998	7213898									
		SP-119	November	10	14W 640781	7213131									
		SP-Limno	December	6	NR	NR									
TE	MF	TE-94	May	6	15W 360132	7212073									
		TE-95	May	7.5	15W 360416	7212847									
TEFF	FF	TEFF-47	May	5.6	15W 363854	7209220									
		TEFF-48	May	11.5	15W 363949	7210013									
WAL	NF	WAL-Limno	January	5	15W 361193	7222282	WAL-1	B & C	9.0	15W 360906	7220511	WAL-SC-1	8.3	15W 360886	7220510
		WAL-Limno	February	11.2	15W 360845	7222058	WAL-2	B & C	8.7	15W 360900	7220489	WAL-SC-2	7.8	15W 360879	7220505
		WAL-Limno	April	5.1	15W 361224	7221652	WAL-3	B & C	7.7	15W 360903	7220464	WAL-SC-3	8.8	15W 360885	7220504
		WAL-79	May	5	15W 360698	7221296	WAL-4	B & C	8.6	15W 360927	7220447	WAL-SC-4	8.4	15W 360894	7220484
		WAL-80	May	7.5	15W 360524	7221622	WAL-5	B & C	9.5	15W 360941	7220425	WAL-SC-5	8.5	15W 360903	7220486
		WAL-81	July	7	15W 360395	7222416	WAL-COMP	C				WAL-SC-6	8.9	15W 360907	7220479
		WAL-82	July	8.5	15W 361960	7222850						WAL-SC-7	8.9	15W 360929	7220484
		WAL-83	August	5.6	15W 360583	7221671						WAL-SC-8	9.5	15W 360945	7220484
		WAL-84	August	7.1	15W 360811	7221849						WAL-SC-9	8.9	15W 360935	7220432
		WAL-85	September	8	15W 360942	7222153						WAL-SC-10	8.2	15W 360936	7220422
		WAL-86	September	5.3	15W 360412	7221319									
		WAL-87	November	7.5	15W 360716	7222032									
		WAL-88	November	10.5	15W 360716	7222032									

Area[1]	Area Type[2]	Area-Replicate	Water & Phytoplankton (monthly)				Benthos & Sediment Grabs (August)					Sediment Cores (August)			
			Month	Depth (m)	Zone & Easting	Northing	Area-Replicate	Sample Type[3]	Depth (m)[4]	Zone & Easting	Northing	Area-Replicate	Depth (m)	Zone & Easting	Northing
WAL	NF	WAL-Limno	December	20	15W 360881	7221997									
INUG	Ref	INUG-98	May	10	14W 622830	7216538	INUG-1	B & C	8.7	14W 622850	7216827				
		INUG-99	May	13.8	14W 622395	7215689	INUG-2	B & C	7.5	14W 622847	7216841				
		INUG-100	July	7.3	14W 622910	7216941	INUG-3	B & C	7.7	14W 622798	721670				
		INUG-101	July	7.6	14W 622970	7214584	INUG-4	B & C	7.2	14W 622782	7216795				
		INUG-102	August	5.9	14W 622942	7216343	INUG-5	B & C	8.8	14W 622687	7216781				
		INUG-103	August	11.2	14W 622507	7216100	INUG-COMP	C							
		INUG-104	September	7.2	14W 622805	7216273									
		INUG-105	September	10.1	14W 622065	7215693									
		INUG-106	November	7.5	14W 622975	7216890									
		INUG-107	November	7	14W 622088	7215966									
PDL	Ref	PDL-63	May	17.5	14W 632216	7224173	PDL-1	B & C	6.5	14W 630624	7223052				
		PDL-64	May	14.7	14W 629998	7223578	PDL-2	B & C	6.5	14W 630618	7223065				
		PDL-65	July	13.3	14W 630080	7223586	PDL-3	B & C	7.7	14W 630685	7222984				
		PDL-66	July	18	14W 632629	7223864	PDL-4	B & C	6.8	14W 630590	7223021				
		PDL-67	August	6	14W 630247	7223212	PDL-COMP	C							
		PDL-68	August	9.4	14W 631152	7223712									
		PDL-69	September	14	14W 631723	7224108									
		PDL-70	September	13.38	14W 630507	7223635									
		PDL-71	November	7	14W 632212	7224444									
		PDL-72	November	7	14W 630285	7223179									
BBD	NF	BBD-55	July	14	14W 644090	7135338	BBD-1	B & C	9	14W 644597	7135277				
		BBD-56	July	5.75	14W 644753	7135305	BBD-2	B & C	7.6	14W 644572	7135299				
		BBD-57	August	11.4	14W 644428	7135253	BBD-3	B & C	7.6	14W 644548	7135317				
		BBD-58	August	9	14W 644600	7135277	BBD-4	B & C	8.4	14W 644507	7135313				
		BBD-59	September	9.48	14W 644376	7135354	BBD-5	B & C	8.7	14W 644419	7135336				
		BBD-60	September	13.6	14W 644853	7135085	BBD-COMP	C							
BPJ	NF	BPJ-55	July	14.3	15W 356938	7134148	BPJ-1	B & C	7.1	15W 357298	7134106				
		BPJ-56	July	15	15W 356888	7134076	BPJ-2	B & C	6.9	15W 357265	7134127				
		BPJ-57	August	15	15W 356416	7134099	BPJ-3	B & C	7.5	15W 357239	7134139				
		BPJ-58	August	10.8	15W 356881	7134252	BPJ-4	B & C	8	15W 357044	7134221				
		BPJ-59	September	11.7	15W 357380	7133979	BPJ-5	B & C	7.5	15W 356999	7134244				

Area[1]	Area Type[2]	Area-Replicate	Water & Phytoplankton (monthly)				Benthos & Sediment Grabs (August)					Sediment Cores (August)			
			Month	Depth (m)	Zone & Easting	Northing	Area-Replicate	Sample Type[3]	Depth (m)[4]	Zone & Easting	Northing	Area-Replicate	Depth (m)	Zone & Easting	Northing
BPJ	NF	BPJ-60	September	16.93	15W 357454	7133888	BPJ-COMP	C							
BES	Ref						BES-1	B & C	8.4	15W 361228	7132390				
							BES-2	B & C	8.1	15W 361278	7132371				
							BES-3	B & C	8.5	15W 361327	7132341				
							BES-4	B & C	8.1	15W 361386	7132312				
							BES-5	B & C	8.3	15W 361447	7132286				
							BES-COMP	C							
BAP	Ref	BAP-55	July	16	15W 362998	7131023	BAP-1	B & C	8.3	15W 363973	7131208				
		BAP-56	July	24	15W 363422	7131027	BAP-2	B & C	7.7	15W 364031	7131178				
		BAP-57	August	9.8	15W 363285	7131316	BAP-3	B & C	7.8	15W 364076	7131156				
		BAP-58	August	14.5	15W 364082	7131015	BAP-4	B & C	7.3	15W 364125	7131154				
		BAP-59	September	16	15W 363774	7131268	BAP-5	B & C	9	15W 364131	7131104				
		BAP-60	September	10.37	15W 364176	7131099	BAP-COMP	C							

Notes
1. Area IDs are as follows:
   TPE, TPN, TPS=Third Portage Lake - East, North, South basins; SP=Second Portage Lake; TE, TEFF=Tehek Lake - Farfield; INUG=Inuggugayualik Lake; WAL=Wally Lake; PDL=Pipedream Lake;
   BBD, BPJ, BES, BAP=Baker Lake - Barge Dock, Proposed Jetty, East Shore, Akilahaarjuk Point.
2. Area types: NF=near-field; MF=mid-field; FF=far-field; Ref=reference.
3. Sample types: B=Benthos; C=chemistry.
4. Comp = composite sample of all 5 replicate samples from each area (no coordinates)

Note that water sampling at BES and sediment/benthic invertebrate sampling at TPS, TE, or TEFF was not completed as per the study design (Azimuth, 2015b).
N/R = depth not recorded (no limno data for this sample

Table 2-3. CREMP sampling coordinates, Whale Tail study area, 2018.

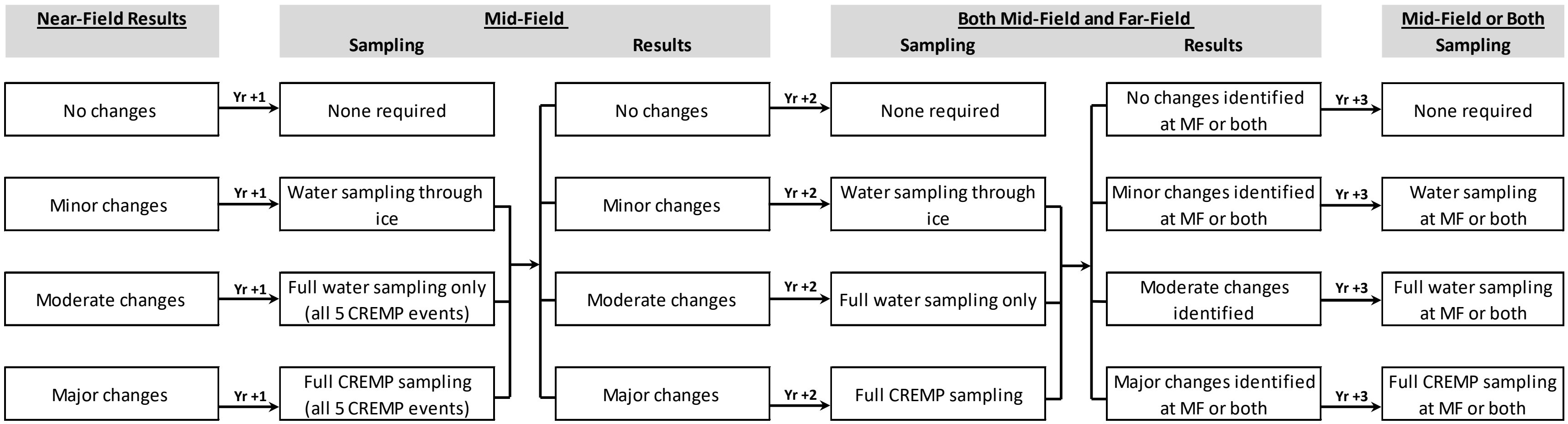
Area[1]	Area Type[2]	Area-Replicate	**Water & Phytoplankton** (monthly)				**Benthos & Sediment Grabs** (August)					**Sediment Cores** (August)			
			Month	Depth (m)	Zone & Easting	Northing	Area-Replicate	Sample Type[3]	Depth (m)[4]	Zone & Easting	Northing	Area-Replicate	Depth (m)	Zone & Easting	Northing
WTS	NF	WTS-27	May	14.8	14W 607376	7253849	WTS-1	B & C	7.2	14W 607147	7253556	SC-1	8.6	14W 607158	7253568
		WTS-28	May	13	14W 607385	7254484	WTS-2	B & C	8.3	14W 607168	7253553	SC-2	8.5	14W 607160	7253553
		WTS-29	July	6.6	14W 607686	7254010	WTS-3	B & C	7.8	14W 607106	7253571	SC-3	8.4	14W 607175	7253542
		WTS-30	July	9.8	14W 607169	7253575	WTS-4	B & C	7.9	14W 607103	7253635	SC-4	9.2	14W 607127	7253585
		WTS-31	August	9.7	14W 607159	7253588	WTS-5	B & C	7.2	14W 607164	7253636	SC-5	7.9	14W 607127	7253594
		WTS-32	August	8.8	14W 607500	7254181	WTS-COMP	C				SC-6	8.0	14W 607128	7253584
		WTS-33	September	9.5	14W 607274	7253485						SC-7	8.0	14W 607135	7253662
		WTS-34	September	5.9	14W 607638	7254078						SC-8	7.6	14W 607133	7253623
		WTS-35	November	5.8	14W 607234	7253585						SC-9	7.9	14W 607110	7253624
		WTS-36	November	14.2	14W 607636	7254046						SC-10	7.9	14W 607096	7253591
		WTS-Limno	December	6.7	14W 607565	7254178									
MAM	NF	MAM-27	May	8	14W 604987	7254820	MAM-1	B & C	8	14W 604987	7254844	SC-1	8.3	14W 605059	7254844
		MAM-28	May	16	14W 604058	7254491	MAM-2	B & C	7.9	14W 605050	7254867	SC-2	8.2	14W 605061	7254854
		MAM-29	July	5.4	14W 604437	7253736	MAM-3	B & C	8.1	14W 605072	7254862	SC-3	8.3	14W 605054	7254815
		MAM-30	July	6.9	14W 604032	7254411	MAM-4	B & C	8.6	14W 605028	7254870	SC-4	7.7	14W 605056	7254798
		MAM-31	August	8.3	14W 604998	7254792	MAM-5	B & C	8.4	14W 605066	7254888	SC-5	8.0	14W 604998	7254831
		MAM-32	August	9.2	14W 604110	7254500	MAM-COMP	C				SC-6	8.2	14W 605008	7254816
		MAM-33	September	7.9	14W 605076	7254879						SC-7	8.0	14W 605008	7254874
		MAM-34	September	9	14W 604318	7254273						SC-8	7.4	14W 605072	7254898
		MAM-35	November	9.1	14W 605360	7255126						SC-9	7.3	14W 605051	7254897
		MAM-36	November	7.4	14W 604263	7253890						SC-10	7.9	14W 605079	7254881
		MAM-Limno	December	5.2	14W 605412	7255062									
NEM	NF	NEM-27	May	10.5	14W 606408	7257020	NEM-1	B & C	6.9	14W 606543	7257286	SC-1	8.4	14W 606547	7257348
		NEM-28	May	12.4	14W 606982	7257823	NEM-2	B & C	8.4	14W 606541	7257319	SC-2	8.3	14W 606547	7257343
		NEM-29	July	8.1	14W 606241	7257371	NEM-3	B & C	6.2	14W 606568	7257333	SC-3	9.3	14W 606526	7257363
		NEM-30	July	7.5	14W 607018	7257843	NEM-4	B & C	7.8	14W 606561	7257354	SC-4	8.5	14W 606548	7257369
		NEM-31	August	12	14W 606592	7257571	NEM-5	B & C	8.2	14W 606534	7257299	SC-5	8.7	14W 606541	7257358
		NEM-32	August	11	14W 606992	7257819	NEM-COMP	C				SC-6	7.5	14W 606544	7257328
		NEM-33	September	11.1	14W 606543	7257487						SC-7	8.8	14W 606525	7257317

Area[1]	Area Type[2]	Area-Replicate	**Water & Phytoplankton** (monthly)				**Benthos & Sediment Grabs** (August)					**Sediment Cores** (August)			
			Month	Depth (m)	Zone & Easting	Northing	Area-Replicate	Sample Type[3]	Depth (m)[4]	Zone & Easting	Northing	Area-Replicate	Depth (m)	Zone & Easting	Northing
NEM	NF	NEM-34	September	13	14W 606184	7257633						SC-8	8.3	14W 606568	7257388
		NEM-35	November	11.4	14W 606983	7257821						SC-9	8.7	14W 606554	7257389
		NEM-36	November	10	14W 606413	7257019						SC-10	8.8	14W 606564	7257371
		NEM-Limno	December	10.1	14W 7257276	606509									
A20	MF	A20-21	May	5.8	14W 601841	7256995	A20-1	B & C	7.6	14W 604566	7252549	SC-1	8.6	14W 604575	7252558
		A20-22	May	6	14W 605222	7252786	A20-2	B & C	8	14W 604595	7252553	SC-2	9.4	14W 604571	7252568
		A20-23	July	5.6	14W 605251	7252790	A20-3	B & C	8.9	14W 604654	7252560	SC-3	8.6	14W 604606	7252566
		A20-24	July	5.6	14W 604701	7252432	A20-4	B & C	8.2	14W 604653	7252555	SC-4	8.5	14W 604614	7252564
		A20-25	August	5.2	14W 605205	7252748	A20-5	B & C	7.7	14W 604657	7252509	SC-5	9.2	14W 604630	7252563
		A20-26	August	6	14W 604703	7252487	A20-COMP	C				SC-6	8	14W 604655	7252542
		A20-27	September	5.9	14W 605225	7252779						SC-7	7.9	14W 604641	7252547
		A20-28	September	7.4	14W 604605	7252513						SC-8	8.6	14W 604668	7252524
		A20-29	November	5.8	14W 604713	7252473						SC-9	7.9	14W 604622	7252501
		A20-30	November	19.5	14W 604387	7252619						SC-10	6.8	14W 604589	7252526
A76	MF	A76-21	May	5	14W 601785	7257005	A76-1	B & C	8.2	14W 602213	7256939	SC-1	7.9	14W 602207	7256946
		A76-22	May	9.2	14W 602154	7256796	A76-2	B & C	8.8	14W 602244	7256914	SC-2	7.4	14W 602228	7257004
		A76-23	July	6.7	14W 602143	7257013	A76-3	B & C	8.9	14W 602272	7256911	SC-3	7.9	14W 602239	7256993
		A76-24	July	11.5	14W 601735	725690	A76-4	B & C	8.1	14W 602263	7256941	SC-4	8.5	14W 602266	7256977
		A76-25	August	6.7	14W 601938	7256930	A76-5	B & C	7.9	14W 602284	7256964	SC-5	8.4	14W 602295	7256981
		A76-26	August	11	14W 602613	7257214	A76-COMP	C				SC-6	7.5	14W 602308	7256964
		A76-27	September	7.5	14W 601858	7256915						SC-7	8.2	14W 602207	7256944
		A76-28	September	8	14W 602587	7257014						SC-8	8.5	14W 602275	7256932
		A76-29	November	8.2	14W 601901	7256915						SC-9	8.2	14W 602251	7256929
		A76-30	November	13.5	14W 602599	7257213						SC-10	8.9	14W 602254	7257019
DS1	FF	DS1-19	May	20	14W 597627	7260888	DS1-1	B & C	9.2	14W 598015	7262038	SC-1	9.5	14W 0598074	7262025
		DS1-20	May	8.1	14W 598020	7258260	DS1-2	B & C	8.6	14W 598121	7262012	SC-2	8.8	14W 0598092	7262074
		DS1-21	July	7	14W 597594	7260905	DS1-3	B & C	8.8	14W 598075	7262024	SC-3	9.3	14W 0598111	7262053
		DS1-22	July	5.1	14W 597971	725827	DS1-4	B & C	9.2	14W 598103	7262133	SC-4	7.5	14W 598119	7261989
		DS1-23	August	16	14W 597539	7260761	DS1-5	B & C	9.5	14W 598045	7262051	SC-5	8.6	14W 598106	7262018
		DS1-24	August	8.1	14W 598017	7258261	DS1-COMP	C				SC-6	8.1	14W598079	7262096
		DS1-25	September	5.6	14W 597576	7261234						SC-7	9.0	14W 598039	7262022
		DS1-26	September	8.5	14W 598080	7258187						SC-8	8.1	14W 597995	7262064

Area[1]	Area Type[2]	Area-Replicate	Water & Phytoplankton (monthly)				Benthos & Sediment Grabs (August)					Sediment Cores (August)			
			Month	Depth (m)	Zone & Easting	Northing	Area-Replicate	Sample Type[3]	Depth (m)[4]	Zone & Easting	Northing	Area-Replicate	Depth (m)	Zone & Easting	Northing
DS1	FF	DS1-27	November	N/R	14W 597587	7260919						SC-9	7.6	14W 598084	7262013
		DS1-28	November	11.6	14W 598051	7258251						SC-10	8.4	14W 598050	72620555

Notes
1. Area IDs are as follows:
   WTS=Whale Tail South; MAM=Mammoth Lake; NEM=Nemo Lake; A20= Lake A20; A76=Lake A76; DS1=Lake DS1
2. Area types: NF=near-field; MF=mid-field; FF=far-field; Ref=reference.
3. Sample types: B=Benthos; C=chemistry.
4. Comp = composite sample of all 5 replicate samples from each area (no coordinates)

Figure 2-1. Annual results-based sampling strategy rules for mid-field and far-field sampling areas.



2.3. Targeted Studies in 2018

2.3.1. Overview

Targeted bioavailability studies were completed at TPE and WAL based on recommendations presented in the 2017 CREMP (Azimuth 2018c). The same methods were used at TPE, WAL, and the Whale Tail areas (MAM and WTN) for assessing sediment metals bioavailability in 2018:

1. Sediment toxicity tests using *Chironomus dilutus* midge larvae and the freshwater amphipod *Hyalella azteca*. Toxicity tests with *C. dilutus* and *H. azteca* provide a direct measure of effects from exposure to current concentrations of metals. In 2018, the sediment toxicity tests passed the quality assurance / quality control assessment (QA/QC) for reliable and accurate data. The test methods are described below in **Section 2.3.5** and in detail in **Appendix G**.

2. Sequential extraction test methods (Pueyo et al., 2001). Sequential extraction testing is a geochemical analysis that subjects a sample to progressively more aggressive digestion methods that provide insights into their availability to biota (i.e., "high" = metals weakly bound in the sediment; "low" = metals strongly sequestered by the sediment matrix). For context, the concentration (mg/kg dw) of a given metal (e.g. chromium) in the residual fraction (i.e., mineral-bound) is estimated by subtracting the sum of the concentration in the three sequential extraction steps from the bulk chemistry analysis:

$$Residual = Total\ - \sum Step\ 1 + Step\ 2 + Step\ 3$$

Where:

Total = the "environmentally available" metal concentration (mg/kg dw)[6].

Residual = estimate of metals that remain once the fractions from Step 1, Step 2, and Step 3 have been removed.

Step 1 (carbonate-bound fraction): Metals in this fraction will desorb with changes in pH.

Step 2 (Fe/Mn oxide bound fraction): Metals in this fraction will only be released under anoxic conditions.

Step 3 (organic matter or sulphide bound fraction): Metals in this fraction will be released under oxidizing conditions, as organic material is degraded.

[6] As per test method EPA 200.2/6202A. Metals bound in the mineral matrix are not solubilized.

The sequential extraction test results failed the QA/QC assessment in two rounds of analysis. In the original set of analyses, the samples were incorrectly processed (i.e., pulverized) by the laboratory prior to analysis using the sequential extraction procedure. The effect on the data was anomalously high concentrations of most metals in sequential extraction steps. Maxxam re-analyzed the sediment samples, but the second set of data produced mass-balance estimates for the residual fraction that were in the negative for most metals. Consistently negative concentrations in the residual were indicative of an underlying issue with the test method. Based on previous used of this method at Meadowbank, a considerable percentage of the total concentration is associated with the mineral matrix. As an example, over 85% of the chromium present in the sediment at TPE, INUG, and PDL occurred in the residual fraction in the 2015 targeted study (Azimuth, 2016). Maxxam was conducting additional analyses on the sediment to determine the source of the error while the 2018 CREMP report was finalized. The sequential extraction test results were not included in the discussion of sediment metals bioavailability at TPE, WAL, or the Whale Tail study areas.

2.3.2. TPE Sediment Bioavailability - Chromium

Chromium concentrations in sediment at TPE have been followed since the first evidence of an increasing trend was noted in the 2012 CREMP (Azimuth, 2013). In 2014, a targeted coring study confirmed the trend as temporal (Azimuth, 2015b). The first round of targeted bioavailability testing was completed in 2015 and involved laboratory sediment toxicity testing and sequential extraction tests. These test results were integrated with the benthic invertebrate taxonomy and sediment chemistry results in weight of evidence (WOE) framework to determine if the benthic invertebrate community is a risk of effects caused by metals from the site. The WOE assessment confirmed the low bioavailability of sediment chromium (i.e., low risk to the benthic invertebrate community), but recommended ongoing monitoring of the temporal trend.

Annual monitoring of sediment chemistry at TPE as part of the routine CREMP through 2017 showed continued increases in chromium concentrations. Based on recommendations in the 2017 CREMP (Azimuth 2018c), a repeat of the 2015 targeted study was undertaken in August 2018 to assess whether the increased chromium concentrations posed unacceptable risks to the benthic invertebrate community at TPE. Chromium bioavailability was assessed using toxicity tests on *C. dilutus* and *H. azteca*. The sediment toxicity test results were integrated with the benthic invertebrate community and sediment chemistry results for TPE. Toxicity test methods are described below in **Section 2.3.5**.

2.3.3. WAL Sediment Bioavailability – Arsenic

Sediment coring as part of the routine CREMP in 2017 indicated concentrations of arsenic were approximately two-fold higher at WAL in 2017 than in the baseline period. While there was uncertainty regarding whether the observed pattern represented a true increase in arsenic or whether it reflected spatial heterogeneity (which was addressed by repeating the 2017 sediment coring study in 2018), targeted bioavailability testing was also recommended to determine if sediment arsenic concentration have the potential to cause adverse effects to the benthic invertebrate community. The same WOE framework used for TPE was applied to the targeted program at WAL.

2.3.4. Sediment Bioavailability for the Whale Tail Project

Baseline toxicity testing was completed on *C. dilutus* and *H. azteca* exposed to sediment Mammoth Lake (MAM) and Whale Tail Lake (north basin; WTN) in 2018 to determine the test organism responses (i.e., growth and survival) prior to development of the Whale Tail Pit deposit. Mammoth Lake was selected because of the potential changes in water and sediment quality due to effluent discharge during operations. The north basin of Whale Tail Lake (WTN) was selected because of the high concentration of arsenic (560 mg/kg to 1,750 mg/kg) measured in 2015 to support the FEIS. Station WTN is located within the footprint of the open pit and will no longer exist after the area is dewatered. However, the high arsenic concentrations provide a benchmark for assessing changes in sediment chemistry at MAM or WTS in the future. Sediment samples were collected and analyzed according to the same methods as TPE and WAL.

2.3.5. Methods

Sediment Collection

Five replicate sediment samples were collected from each area (i.e., discrete field replicates). Each replicate was a composite of the top 3-5 cm from enough ponar grabs to fill two 1-L HDPE plastic jars. Sediments were collected according to the SOP used to sample sediment for bulk chemistry (Azimuth, 2015a). The top 3-5 cm was homogenized in the field and before transferring to the two 1-L HDPE plastic jars. The samples were refrigerated until being shipped to Maxxam Analytics Inc. (Burnaby, BC) for sequential extraction analyses (not reported) and Nautilus Environment (Burnaby, BC) for sediment toxicity testing.

Laboratory Toxicity Tests

Two benthic invertebrate species were used to assess whether the elevated metals have the potential to cause sediment toxicity: an amphipod (*Hyalella azteca*) and a midge larva (*Chironomus dilutus*). The endpoints for both species were survival and growth.

- The *Hyalella* test is a static test using juvenile (7-9 days old) amphipods, exposed to whole sediment for 14-days. This test was conducted at 23°C, using the 5 replicates per treatment including a laboratory control, with 10 organisms per replicate.
- The *Chironomus* test is a static, non-renewal test using 3rd instar midge larvae exposed to whole sediment for 10-days. This test was conducted at 23°C, using the 5 replicates per treatment including a laboratory control, with 10 organisms per replicate.

Detailed test methods are provided in **Appendix G**.

Results from the toxicity tests, combined with the benthic community surveys and sediment chemistry results, provide a robust means of assessing the ecological significance of elevated concentration of metals in aquatic systems.

2.4. Data Evaluation Criteria

The specific methods used to apply triggers/thresholds in the evaluation of CREMP monitoring parameters varied by study component; details are presented in the following sections. The evaluation process focused on comparisons to early warning triggers; only when triggers were exceeded were monitoring results compared to thresholds. Consequently, methods for applying numerical decision criteria focus on triggers only, but apply equally to threshold values.

2.4.1. Water Chemistry

Water quality data collected in 2018 were evaluated against triggers and thresholds consistent with the existing framework outlined in the *CREMP: 2015 Plan Update* (Azimuth 2015b). Formal comparison of the water quality data for decision-making purposes was done by comparing the yearly mean[7] parameter concentrations to the trigger values developed separately for the Meadowbank projects lakes, Wally Lake, and Baker Lake areas[8]. Those parameters where the

[7] Yearly means were calculated by first calculating the monthly mean for each parameter per area, then calculating the yearly mean on an area-specific basis. Values that were less than the MDL were conservatively set to the MDL.

[8] Separate water quality triggers were developed for Wally Lake from the other Meadowbank areas when mining activities transitioned from the North and South Portage Pits (discharge to TPN) to the Vault Lake area (discharge to WAL) in 2013.

yearly mean was equal to or exceeded the trigger value were formally tested using a one-tailed test of the null hypothesis[9] (significance level of p=0.05) according to the framework outlined below for Meadowbank and Baker Lake areas. For the Whale Tail study area lakes, formal statistical BACI analysis of the water quality results was deferred until 2019 because of the limited amount of 'after' data that was available for the impact areas (**Table 2-4**). The approach taken for assessing water quality for the Whale Tail study area lakes is described below.

- **Meadowbank Project Lakes and Wally Lake** – A Before-After-Control-Impact (BACI) statistical framework was applied. The BACI model is "paired" (i.e., BACIP) when multiple "before" and "after" events are available. In the BACI model, INUG is used as the reference ("control") area, and the other areas are tested as exposure ("impact") areas. PDL and TEFF are excluded as control areas in the BACI analysis because neither area was sampled in the "before" period between 2006 and 2008 (i.e., limiting their utility as reference areas in the BACI model, but both providing valuable context for interpreting the strength and consistency of regional trends seen at INUG). True "pre-impact" data (i.e., when both INUG and the test area had "control" ("C") status; see **Table 2-4**) were used for the "before" data. Only events when both INUG and the test area were sampled in 2018 were used as the "after" data.

  In addition to the trigger/threshold BACI evaluation, annual Meadowbank CREMP water chemistry data were also compared to the maximum whole-lake average water quality modelling predictions for Third Portage, Second Portage, and Wally Lakes made during the environmental assessment process (Cumberland 2005). While direct comparisons were made, the difference in spatial focus (i.e., the CREMP at the basin scale and the water quality model at the whole-lake scale) warrants caution interpreting any differences. To that end, the assessment criteria outlined in the Final Environmental Impact Statement (FEIS; Cumberland 2005) for defining the predicted magnitude of impacts to water quality will be used to provide the appropriate context for interpreting the screening results as follows:

  - **Negligible**: water quality concentrations are similar to baseline
  - **Low**: concentrations are < 1x the CCME Water quality guideline (WQG)
  - **Medium**: concentrations are between 1 and 10-times the CCME guidelines
  - **High**: concentrations are less than MDMER but greater than 10-times the CCME guidelines
  - **Very High**: concentrations exceed MDMER standards

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[9] The null hypothesis is "test" area concentrations either did not change or decreased. The alternative hypothesis is that they increased.

- **Baker Lake** – Baker Lake areas were designated as "control" (BAP) or "impact" (BPJ and BBD) when sampling started in 2008 (i.e., there was no detailed baseline sampling was conducted for Baker Lake; see **Table 2-4**), so there are no true "pre-impact" "before" data. While a spatial "CI" design could be used to test for differences between reference "control" and exposure "impact" areas, the design does not allow for distinguishing natural differences between areas from development-related changes. Given that no development-related changes had been identified to date, all years of data up to and including 2017 were considered in the "before" period while the 2018 results were considered "after" period data (i.e., allowing the more robust BACI analysis). Thus, the BACI analyses specifically looked at changes in 2018 at the two "impact" areas relative to previous years.
- **Whale Tail** – For 2018, assessment of spatial and temporal trends related to construction activities was conducted using CCME water quality guidelines and close visual scrutiny of time series plots for each parameter.

  Next year's water quality assessment will follow the framework described above for Meadowbank: 1) yearly-mean concentrations in each area will be compared to Whale Tail-specific trigger values, 2) formal BACI analysis of temporal changes for those parameters that exceed their triggers (i.e., are higher relative to baseline/reference conditions), and 3) comparison of the annual water quality data against water quality predictions in the FEIS (Volume 6, Golder 2016).

  Trigger development will be undertaken pending completion of site-specific water quality objectives (SSWQO) for Whale Tail. A long-term SSWQO for arsenic of 28 µg/L was developed as part of the FEIS submission (see Appendix 6-N in Volume 6 of the FEIS [Golder 2016]). Moving forward, this SSWQO will serve as the arsenic 'threshold' for the Whale Tail study area lakes. Triggers will be developed according to the following methods described in Azimuth (2012d):

  - *When a threshold (e.g., SSWQO or CCME water quality guideline) is established, the trigger was set as the maximum of either (a) the value halfway between the baseline median and the threshold ("Method A"), or (b) the 95th percentile of the baseline data ("Method B").*
  - *When a threshold is not established, the trigger was set equal to the 95th percentile of the baseline data ("Method B"), except in cases where less than 5% of the data exceeded the current detection limit (DL) – in the latter case, the trigger was set equal to two times the DL ("Method C").*

2.4.2. Sediment Chemistry

Sediment grabs samples are collected annually synoptically with the benthic invertebrate samples. In addition to characterizing physical conditions (e.g., grain size and organic carbon content), they provide additional information on temporal changes in sediment metals concentrations. The sediment grab chemistry results are evaluated against the sediment triggers, but BACI statistical analysis is limited to core samples collected every three years.

Sediment chemistry core sampling for the CREMP is completed every three years and is intended to detect long term trends in metals concentrations in the top layer of sediment (1.5 cm [approximately]). Coring is completed at the same time as Environmental Effects Monitoring (EEM) sampling on three-year cycle. The next full coring program is scheduled for 2020 (coinciding with the EEM program), but follow-up coring at TPE and WAL was recommended for 2018 to verify the temporal trends of increasing chromium at TPE and arsenic at WAL in the 2017 CREMP report.

Trends in sediment chemistry data from TPE and WAL were evaluated by comparing the yearly mean parameter concentrations in the core samples to the updated trigger values applicable to TPE and WAL[10]. Those parameters where the yearly mean was equal to or exceeded triggers were formally tested using a before-after (BA) statistical model[11]. Sediment chemistry can be quite variable over a small spatial scale within a given basin, but natural seasonal variability in sediment chemistry is assumed to be low given the low rates of natural sediment deposition in Arctic lakes (Azimuth, 2012d). The BA statistical model assumes that, in absence of mining-related inputs, annual variability in sediment chemistry is negligible.

Triggers specific to the Whale Tail study areas will be developed and implemented prior to the next sediment coring program scheduled for August 2020 (3-year cycle). Evaluation of the data will follow the same approach used for Meadowbank by comparing the yearly mean concentrations to new trigger values and BA statistical analysis of temporal changes for parameters that exceeded their respective triggers. Triggers will be developed using the baseline sediment core chemistry data collected in 2017 and the statistical approach described in Azimuth (2012d). Briefly, for sediment chemistry parameters with thresholds (i.e., CCME sediment quality guidelines), the trigger is set as the maximum concentrations of either (a) the

[10] The trigger values for the Meadowbank project lakes were updated 2017 CREMP report. New trigger values specific to WAL were developed for the 2017 CREMP.

[11] One-tailed test of the null hypothesis that concentrations are not different (or lower) in the after period relative to the before period (significance level of p=0.05); the alternate hypothesis is that concentrations have increased in relation to mining.

value halfway between the baseline median and the threshold ("Method A"), or (b) the 95th percentile of the baseline data ("Method B").

2.4.3. Phytoplankton and Benthos Community Variables

Trigger and threshold value development for phytoplankton and benthos communities was presented in detail in the original CREMP Design Document (Azimuth, 2012d). Unlike water or sediment, where environmental quality guidelines can be used to develop thresholds or triggers, there are no universal benchmarks for biological variables such as abundance, biomass or diversity. Rather, the magnitude of change or difference relative to expected conditions must be used to establish "critical effect sizes" (CES) for biological variables. Effect sizes of 20% and 50% were established as the "trigger" and "threshold" for assessing changes in biological variables. Importantly, the terms "threshold" and "trigger" for biological variables are not used as strictly as for water and sediment chemistry parameters for two reasons:

1. Statistical Power - For most biological variables, natural variability can make it difficult to statistically detect effect sizes as low as 20%. It is more realistic to detect larger effect sizes such as 50%.
2. Causality – Even if statistically-significant changes are documented (at whatever effect size), the cause of the change needs to be understood in order to effectively manage the situation. For the Meadowbank biological data, effect sizes exceeding 50% have been observed due to natural variability in the baseline data.

The BACI framework developed for the phytoplankton and benthos community assessments at Meadowbank will be implemented at Whale Tail now that the Project has transitioned from the 'before' to the 'after' period in 2019.

Phytoplankton Taxonomy

Total phytoplankton biomass and taxa richness were selected as the metrics to assess changes in the phytoplankton community using the BACI framework[12]. Phytoplankton triggers and thresholds are set to relative changes of 20% and 50%, respectively. The evaluation procedure was analogous to that used for water chemistry, except that area means for 2018 were not directly comparable to triggers (i.e., since the triggers/thresholds are based on the relative change over time in a parameter rather than on a finite value), so the process started with the

[12] BACI framework involves paired monthly sampling events at "control" [INUG or BAP] and "impact" [i.e., NF or MF areas] areas over two periods ["before" and "after"], with "months" as the unit for temporal replication).

BACI testing. Two-tailed tests of the null hypothesis (i.e., that test areas experienced no relative change up or down) were conducted with a significance level of p=0.1.

Benthos Taxonomy

Trigger and threshold values for the benthos are set at reductions of 20% and 50%, respectively for abundance and taxa richness. The CREMP uses percent change rather than standard deviations which are used in EEM, to maintain a transparent (fixed) effect size that is more likely to be ecologically relevant. Statistical power increases with consideration of more "after" period years; consequently, BACI analyses were conducted on four "after" data period lengths: one year (2018 only), two years (2017-2018), three years (2016-2018), and four years (2015-2018). One-tailed tests of the null hypothesis were conducted with a significance level of p=0.1. Failure to reject the null hypothesis implies *the endpoint (i.e., total abundance or species richness) either did not change or increased*. The alternative hypothesis is that the endpoint decreased. Despite this BACI being conducted as a one-tailed test, the p value was left at 0.1 to help improve statistical power for the benthic invertebrate endpoints.

No baseline benthic community data are available for Baker Lake, so there are no true "pre-impact" "before" data. While a spatial "CI" design could be used to test for differences between reference "control" and exposure "impact" areas, the design does not allow for distinguishing natural differences between areas from development-related changes. Rather, since no development-related changes had been identified to date, BACI analyses for Baker Lake benthos were conducted using a series of four temporal scenarios using all 11 years of data. (i.e., 2018 was compared to 2008-2017; 2017/2018 was compared to 2008-2016…and so on). This series of comparisons provides a more robust means to identify temporal changes due to mining-related activities in Baker Lake without needing to assume that sampling areas should have identical communities (i.e., like the CI design).

Figure 2-2. Management response plan for the Meadowbank Mine Aquatic Environment Monitoring Program (AEMP).

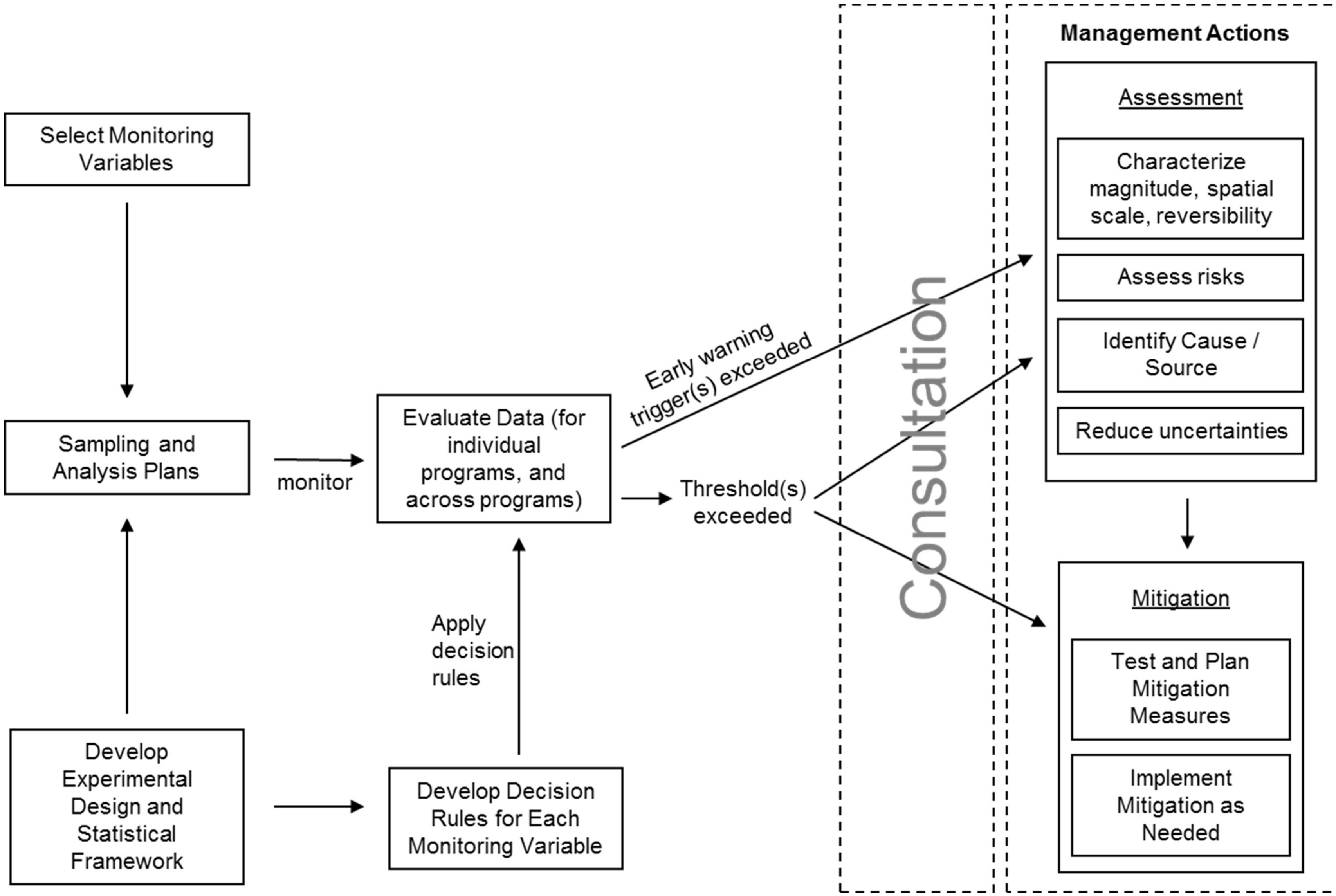


Table 2-4. Status of all CREMP sampling areas since the beginning of monitoring.

Area	Meadowbank Areas									Baker Lake Areas				Whale Tail Pit Areas					
Designation	**REF**	**REF**	**NF**	**NF**	**NF**	**NF**	**MF**	**MF**	**FF**	**REF**	**REF**	**NF**	**NF**	**NF**	**NF**	**NF**	**MF**	**MF**	**FF**
Station	**INUG**	**PDL**	**TPN**	**SP**	**TPE**	**WAL**	**TPS**	**TE**	**TEFF**	BAP	BES	BBD	BPJ	WTS	MAM	NEM	A20	**A76**	**DS1**
2006	C		C	C	C	C	C	C											
2007	C		C	C	C	C	C	C											
2008	C		C	I (Aug)	C	C	C	I (Aug)		C		I	I						
2009	C	C	I (Mar)	I	I (Aug)	C	C	I	C	C		I	I						
2010	C	C	I	I	I	C	C	I	C	C		I	I						
2011	C	C	I	I	I	C	C	I	C	C	C	I	I						
2012	C	C	I	I	I	C	C	I	C	C	C	I	I						
2013	C	C	I	I	I	I (Jul)	C	I	C	C	C	I	I						
2014	C	C	I	I	I	I	C	I	C	C	C	I	I	C	C	C			
2015	C	C	I	I	I	I	C	I	C	C	C	I	I	C	C	C			
2016	C	C	I	I	I	I	C	I	C	C	C	I	I	C	C	C	C	C	C
2017	C	C	I	I	I	I	C	I	C	C	C	I	I	C	C	C	C	C	C
2018	C	C	I	I	I	I	C	I	C	C	C	I	I	I (Aug)	I (Nov)	C	C	C	C

Notes:
Area designations:
C=Control; I=Impact; REF=reference (in grey shading); NF=near-field (in blue shading); MF=mid-field (in pink shading); FF=far-field (in teal shading)
Blank cells indicate the area was not part of the monitoring program that year.
Area IDs:
Meadowbank and Whale Tail Pit Reference areas:
INUG = Inuggugayualik Lake; PDL = Pipedream Lake
Meadowbank areas:
TPN, TPE, TPS = Third Portage Lake - North, East, South basins; SP = Second Portage Lake; WAL = Wally Lake; TE, TEFF = Tehek Lake (Mid-field and Far-field)
Baker Lake areas:
BAP, BES, BBD, BPJ=Baker Lake - Akilahaarjuk Point, East Shore, Barge Dock, Proposed Jetty.
Whale Tail Pit areas
WTS = Whale Tail Lake South Basin; MAM = Mammoth Lake; NEM = Nemo Lake; A20 = Lake A20; A76 = Lake A76; DS1 = Lake DS1

3. QUALITY ASSURANCE / QUALITY CONTROL

3.1. Overview of CREMP QA/QC

The objective of quality assurance and quality control (QA/QC) is to assure that the chemical and biological data collected are representative of the material or populations being sampled, are of known quality, have sufficient laboratory precision to be highly repeatable, are properly documented, and are scientifically defensible. Data quality was assured throughout the collection and analysis of samples using specified standardized procedures, by the employment of laboratories that have been certified for all applicable methods, and by staffing the program with experienced technicians.

The framework of the QA/QC program is outlined in *CREMP: 2015 Design Document* (Azimuth 2015b). The Design Document is the foundation for assessing data quality in for each routine component of the CREMP (e.g., water, sediment, etc.) and was adopted for the Whale Tail Pit baseline sampling program (Azimuth 2018b). QA/QC assessments for the Meadowbank / Baker Lake CREMP and Whale Tail Pit baseline CREMP were harmonized in 2018 into one overarching QA/QC program. Detailed analysis of the data quality for each component of the CREMP is provided in **Appendix A**. A summary of the key messages from the 2018 QA/QC program is provided in the subsections below.

3.2. Sample Shipping and Handling

Sample shipping and handling concerns document in previous CREMP reports have largely been rectified in recent years. The ALS laboratory report QA/QC summaries are integrated into **Table A2-2** in **Appendix A**.

Internal cooler temperatures for 2018 were similar to previous years and reflect seasonal ambient temperatures (internal temperatures range from 5°C in November to a high of 22°C in July). The effect on preserved samples is considered negligible, but for chlorophyll-a samples the increase in temperature means samples may arrive thawed. However, keeping the chlorophyll-a samples frozen is a recurring challenge for this program given the logistics of shipping samples from Nunavut to Vancouver in a timely fashion.

There were some broken containers for both water and sediment shipments. However, the percentage of broken containers was extremely low for water and very low for sediment. There is no follow-up for water sample shipments. Sediment sample shipping procedures will be discussed prior to the field season in August. There were also some discrepancies between CoCs and sample ID labels. The discrepancies were addressed prior to sample analysis and did not impact the results in 2018.

3.3. Water Chemistry

Briefly, the standard QA procedures for the water chemistry program include thoroughly flushing the flexible tubing and pump to prevent cross-contamination between areas. Field QC procedures include collection and/or analysis of field duplicates and blanks (travel, equipment, and deionized water blanks). The laboratory QC program includes duplicate analysis, blanks, and analysis of spike samples and reference material to verify the accuracy and precision of the analytical method.

The objectives and methods for surface water QA/QC are outlined in detail in **Appendix A**. Result of the water chemistry QA/QC program are:

- Field and laboratory duplicate samples showed a high degree of precision in 2018. The few exceedances of the established data quality objectives (DQOs) represent much less than 1% of the total for QA samples and parameters measured – there were only nine out of over 1,200 field duplicate RPD values that exceeded 50%. When comparing results for a large number of parameters, many of which are near detection limits, simple odds dictate that a few parameters will exceed DQOs due to laboratory variability (i.e., a false positive). Overall, there was no pattern in the nature of the exceedances that indicates a bias of specific parameters one way or another.
- Four water quality results were flagged as unreliable and excluded from formal analysis: (total copper in WAL-79 [May], dissolved Zinc in SP-111 [May], dissolved chromium in TSP-60 [May], and dissolved lead WAL-81 [July]). The results were flagged as outliers during initial analysis of the data. For transparency, the results are shown in the water quality tables provided in **Appendix B**, but they are excluded from the formal BACI analysis and plots.
- Results from the DI blanks and travel blanks did not warrant flagging any parameters as cautionary or unreliable in the 2018 analyses.
- The implication of possible cross-contamination on interpretation of the 2018 water quality data was evaluated by comparing the sample concentrations with the equipment blank results from the same event. Sample results in **Appendix B1** (Meadowbank), **Appendix B2** (Whale Tail), and **Appendix B3** (Baker Lake) were given a cautionary flag using underlining (e.g., <u>0.001</u>) to indicate that the measured concentration was less than 5-times the concentration detected in the equipment blank. Of the analytes detected in the equipment blanks, lead, manganese, barium, calcium, and strontium (among others) were often given a

"cautionary" flag because the concentrations were consistently within 5-times the MDL, meaning there is potential for cross-contamination to bias the sample results higher. Analysis of the water quality data relative to the triggers and thresholds was done on the entire data set, including the cautionary flagged data. No analyte given a cautionary flag exceeded the trigger or threshold values for 2018. Overall, potential cross-contamination is considered unlikely to bias interpretation of the 2018 water quality analysis.

Except for the four measurements that were flagged as unreliable, the water quality data passed the QA/QC assessment and are reliable for data analysis and interpretation of spatial and temporal trends.

3.4. Sediment Chemistry

The sediment chemistry QA/QC assessment is comprised of field and laboratory duplicates, filter swipes for cross-contamination, and the QC report from ALS for sediment grab and core samples submitted in 2018. Key results of the sediment chemistry QA/QC presented in **Appendix A** are:

- The RPD results indicate a high degree of accuracy between field samples and duplicates; only six RPD results out of 840 exceeded the data quality objective of 50%.
- There were no laboratory duplicate flags in 2018.
- The filter swipe results for 2018 are an improvement on 2017 and the potential for cross-contamination between samples and sample replicates is considered very low.

Sediment chemistry data collected in 2018 passed the QA/QC assessment and are reliable for data analysis and interpretation of spatial and temporal trends.

3.5. Phytoplankton Taxonomy

Field duplicates are collected for phytoplankton during each sampling event in coordination with water sample duplicates and are taken in order to assess sampling variability and sample homogeneity. A RPD of 50% for density and biomass concentrations is considered acceptable. As a measure of laboratory QA/QC on the enumeration method, replicate counts are performed on 10% of the samples. Replicate samples are chosen at random and processed at different times from the original analysis to reduce biases.

Detailed analysis of the phytoplankton data quality is included in **Appendix A**. Results of the phytoplankton QA/QC assessment are:

- There were two minor exceedances of the field duplicate data quality objective for total biomass. Both samples were collected in the winter when phytoplankton biomass levels were low, so the absolute differences were small compared to summer biomass.

Phytoplankton taxonomy results passed the QA/QC assessment and are reliable for data analysis and interpretation of spatial and temporal trends.

3.6. Benthos Taxonomy

Quality assurance measures in the field involved adherence to the standardized method for collecting, sieving, and preserving samples for taxonomic identification (see Appendix B in Azimuth, 2015b). The laboratory (ZEAS) QA/QC procedures include re-sorting and re-counting 10% of the samples targeting > 90% recovery. Detailed analysis of the benthos taxonomy data quality is included in **Appendix A**. Results of the QA/QC assessment are:

- Percent recovery was above 92% in all re-sorted samples, with an average percent recovery of approximately 95.7%.

The benthos taxonomy data collected in 2018 passed the QA/QC assessment and are reliable for data analysis and interpretation of spatial and temporal trends.

3.7. Sediment Toxicity Testing

Sediment toxicity tests for the targeted studies in 2018 were carried out according to standardized test methods published by Environment Canada (1997 [*Chironomus dilutus*]; 2013 [*Hyalella azteca*]). The tests methods prescribe how the tests are conducted, including ambient temperature, light intensity, photo period, and feeding regimen. Test acceptability was assessed by evaluating:

1. Daily water quality monitoring for routine parameters (temperature, dissolved oxygen, pH, specific conductivity,
2. Ammonia concentrations in the overlying water,
3. use of reference toxicant tests to confirm test organism survival is within the reported range,
4. minimum survival and dry weight in the laboratory control treatments.

Detailed test conditions for the *H. azteca* and *C. dilutus* sediment toxicity tests are provided in **Appendix G**. Results of the QA/QC assessment are:

- Temperature, dissolved oxygen, conductivity, and pH were within the range of acceptability specified in the Environment Canada test protocols. Conductivity measured in the overlying water of the *H. azteca* control sediment treatment was between 400 and 500 µS/cm. By comparison, the range in conductivity reported for TPE was approximately 330 to 370 µS/cm.

- Total ammonia concentrations at the start and end of the tests were below concentrations associated with effects to either species. Unionized ammonia measured in the reference sediment (i.e., lab control) were below 0.2 mg/L throughout the *H. azteca* test; no overlying water changes were required.
- Reference toxicant tests for *H. azteca* (NaCl) and *C. dilutus* (KCl) were within the historical range, verifying that the batch of organisms were appropriately sensitive for the sediment toxicity tests.

The sediment toxicity test results passed the QA/QC assessment for data acceptability.

4. MEADOWBANK

4.1. Overview of the 2018 Meadowbank CREMP

This section of the CREMP report summarizes the water quality monitoring results, sediment chemistry, phytoplankton, community, and benthic invertebrate communities in support of the Meadowbank CREMP in 2018. Figures and tables relevant to the Meadowbank project lakes are organized at the end of the section.

The 2018 CREMP focused on monitoring changes in the NF study areas in Third Portage Lake (East Basin [TPE] and North Basin [TPN]) Second Portage Lake (SP) and Wally Lake (WAL). Reference area sampling at INUG and PDL was completed concurrently to sampling at the NF areas. Water quality at TE, TEFF, and TPS was monitored once during the early season sampling event in May, but deferred for the rest of the year based on results of the 2017 CREMP[13]. In addition to routine CREMP sampling at the NF areas, targeted bioavailability studies were conducted at TPE and WAL in 2018. Water quality sampling locations for the 2018 CREMP are shown in **Figure 4-1**. The sediment and benthos sampling areas are shown in **Figure 4-2**.

Mining activities in 2018 were focused on Vault Pit and Pit A, Pit E and Phaser Pit. There was no discharge from the Vault Attenuation Pond to Wally Lake in 2018. Second Portage received discharge from the East dike (North-South) all year except from June 3rd to August 20th; discharge was stopped for increasing TSS levels as no treatment is available for this location.

4.2. Limnology

Limnology data, when compared to previous monitoring data, provides an initial assessment of whether conditions are changing within a sampling area that may require additional follow-up investigation. At least one depth profile for temperature, dissolved oxygen, and conductivity was conducted monthly from NF areas except when ice conditions were unsafe in June and October[14]. Two profiles were conducted during the open water period, occurring synoptically with water chemistry and phytoplankton sampling in May, July, August, and September. **Section 2.2**, outlines the CREMP monitoring plan for routine CREMP sampling years (i.e., when analysis from the previous monitoring year does not flag potential concerns that may warrant greater

[13] There were no trigger exceedances for parameters with effects-based thresholds at the NF areas in 2017. Consistent with the new monitoring strategy implemented in 2015, sediment chemistry or benthic invertebrate community sampling was not required at MF and FF areas in 2018.

[14] March was also not sampled in 2018 due to mechanical issues with the tundra buggy.

sampling resolution). In routine years there are five water sampling events and in 2018, November water sampling was added because it was not possible to collect the March samples. Qualitative evaluation of the limnology data is done using plots of the deepest sample within each lake for a given event. The table below indicates which samples were used in the limnology plots and data interpretation for 2018. Raw limnology data for 2018 is included for in **Appendix H**.

4.2.1. General Observations

The ice-free season on the Meadowbank study lakes is very short. Ice break-up usually occurs during mid- to late-June; ice begins to form again on the lakes beginning in late September or early October, with complete ice cover by late October. Maximum ice thickness is about 2 m and occurs in March/April, increasing the concentration of some ions, such as chloride, in the water near the ice-water interface. This phenomenon is due to cryo-concentration where ice formation excludes certain ions and increases their concentration in the water column (Wetzel, 1983). Because the lakes are ice covered for most of the year, gas exchange with the atmosphere is limited, although oxygen concentrations usually remain high under the ice because of the low rates of biological activity and decomposition of organic material (processes that consume oxygen from the water). Historically, during winter there is typically a slight negative thermal stratification with near 0°C water near the ice-water interface, increasing to 3°C to 5 °C at depth.

During open water conditions, maximum water temperatures may reach 15°C in summer (e.g. July at SP) with little evidence of thermal stratification, except for brief periods of time (days) and typically only a 4°C to 5°C temperature difference. Winds blow near constantly and at high speeds, maintaining uniform temperature and high oxygen profiles in the water column in all lakes due to vertical mixing

4.2.2. Temporal and Spatial Trends

Limnology profiles were recorded monthly throughout the year in 2018 except for March, June, and October (**Table 4-1**).

Temperature and Dissolved Oxygen

Water temperatures at a depth of 3 m are shown in **Figure 4-3** for the Meadowbank project lakes since 2006. Water temperatures in 2018 followed similar patterns of seasonal change compared to previous monitoring cycles.

Table 4-1. Samples included in the limnology profiles in 2018.

Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
INUG			Not sampled		INUG-99	Not sampled	INUG-101	INUG-10	INUG-105	Not sampled	INUG-106	
PDL					PDL-66		PDL-66	PDL-68	PDL-69		PDL-71	
TPN	☑	☑		☑	TPN-111		TPN-112	TPN-114	TPN-117		TPN-119	☑
TPE	☑	☑		☑	TPE-111		TPE-112	TPE-115	TPE-116		TPE-118	☑
SP	☑	☑		☑	SP-111		SP-113	SP-114	SP-116		SP-118	☑
WAL	☑	☑		☑	WAL-80		WAL-81	WAL-84	WAL-85		WAL-88	☑
TPS					TPS-60							
TE					TE-94							
TEFF					TEFF-48							

Notes:

Empty cells indicate no limnology profiles were collected, consistent with the study design.

☑ = One profile is collected from the near-field areas in months where water sampling is not completed.

The 2018 vertical temperature profiles are characteristic of the typical thermal regime of these lakes (**Figure 4-4** through **Figure 4-12**). Winter temperature profiles for the through-ice events show a slight negative thermal stratification with water temperatures near 0°C at the ice-water interface, increasing to typically between 2°C and 3.5°C at depth. Oxygen concentrations in winter generally decrease slightly with increasing depth, with occasional values measured above theoretical limits of air saturation[15] (14.6 mg/L at 0°C). Oxygen concentrations in all basins are greater than 5 mg/L, and usually greater than 10 mg/L even at the lowest depths, despite nearly nine months of ice cover.

The project lakes typically turn over by mid-July, leading to a well-mixed water column with uniform temperature and high oxygen concentrations. Water temperatures warm rapidly to reach maximum temperatures of around 15°C by late July and into August. Deeper lakes and basins, such as TPN and INUG, are typically 2°C to 3°C colder than the shallower locations WAL and SP. Temperatures in 2018 were moderate and typical of historical temperature patterns (**Figure 4-3**). Unlike in 2017 when there was evidence of vertical stratification in some lakes in July, there was little or no evidence of vertical stratification in 2018 from July through November in all lakes. In September, water temperatures cooled to below 5°C but remained un-stratified. With vertical mixing, oxygen concentrations are high and fully saturated (**Figure 4-10**). While the

[15] Photosynthesis occurring under ice can lead to DO results exceeding theoretical air saturation limits. This is due to photosynthesis producing pure oxygen, as opposed to the approximate oxygen content of 21% in air.

values jumped around slightly, no vertical stratification was observed. The November and December sampling events at the NF areas indicate the water column was generally well mixed and still largely un-stratified. DO showed some evidence of stratification; however, the minimal stratification appears near the surface and may be influenced by measuring through the ice-cover (**Figure 4-11** and **Figure 4-12**, respectively).

The seasonal patterns in water temperature and oxygen concentrations observed in 2018 were typical of this area of the Arctic and similar to what has been observed in previous years. There were no differences in these patterns between the control lakes (INUG and PDL) and the NF and MF monitoring areas.

Conductivity

Field conductivity[16] is discussed as an indicator of stratification in the water column. From a monitoring perspective, uniform conductivity provides confidence that the water column is well-mixed and that a water chemistry sample will be representative. In contrast, variable conductivity may indicate the presence of water with different chemical properties (e.g., mining effluent), so profiling is useful to identify these situations and adjust sample collection, if necessary, to ensure that the different water masses are properly characterized. Oligotrophic systems with low dissolved solids and ions (Ca, Na, Cl, Mg, etc.) typically register conductivity measurements of less than 50 µS/cm. Conductivity is usually uniform in concentration from top to bottom at impact and reference lakes in any given month, with minor seasonal fluctuations between months. While the overall range in conductivity is similar between ice-on (10 – 50 µS/cm) and ice-off (10 – 40 µS/cm) months, the conductivities in ice-off months are generally lower, consistent with cryo-concentration during progressive ice formation during winter months.

Field conductivity was generally uniform in concentration through the water column among the various areas sampled in 2018. Minor vertical differences due to cryo-concentration were observed during winter sampling events (e.g., February and December [**Figure 4-5** and **Figure 4-12**, respectively]), with no apparent differences between reference and near-field areas and fairly uniform profiles during the open water period.

Effluent discharge occurred only in SP in 2018. Seep water from the East Dike was collected and diverted back to SP via the diffuser for much of the year (except between June 3rd and August 21st). The release of seep water to SP was stopped because of elevated TSS and there being no treatment available at this location. Agnico Eagle was in full compliance with discharge limits

[16] Throughout this report, any discussion of “conductivity” refers to specific conductance, which is conductivity normalized to 25°C.

specified in their Water Licence and under MDMER. A review of the conductivity values dating back to 2009 showed 2018 conductivity results at SP were generally within the range reported in previous monitoring cycles. Historically, conductivity at SP was typically between 20 µS/cm and 30 µS/cm. More recent results from 2015-2017 have trended more towards 30 µS/cm to 40 µS/cm in most months. The change in conductivity at SP has been previously identified in the water chemistry BACI analysis (see **Section 4.3** and **Figure 4-14** for more details), but has not been linked to any corresponding adverse effects to the biological community.

The highest field conductivity measurements of 2018 occurred at WAL, despite direct discharges from Vault being discontinued in 2018. In 2018, conductivity at WAL peaked in May (85.6 µS/cm), then stabilized for the remainder of the year (July through December) at around 40 µS/cm. Conductivity readings at PDL in May were also elevated – greater than 50 µS/cm in May, which was a four-fold increase over the same period in 2017. There are no mine influences on PDL and the elevated conductivity observed in that lake in May was not evident in other lakes with the exception of WAL. For the July sampling, the WAL conductivity readings were approximately 40 µS/cm at all depths (**Figure 4-8**) – close to the reported concentrations for July 2017. For the months of August through December the conductivity in WAL was similar or less than SP and for the month of September the recorded conductivity in WAL was less than the recorded conductivity in PDL (**Figure 4-10**).

4.3. Water Chemistry

Tabulated water quality data for 2018 are presented in **Appendix B1**. Water chemistry samples were collected synoptically with limnology for the months of May, July, August, September, and November (see **Section 4.2** for limnology results).

4.3.1. General Observations

The general conditions affecting water quality in this region were described in **Section 4.2**. Key points to recall are:

- The Meadowbank study lakes are generally nutrient-poor, thermally un-stratified and well-mixed (uniform temperature and oxygen profiles), with no winter anoxia beneath an ice cover.
- The Meadowbank study lakes are headwater lakes, so there are no significant natural sources of nutrients or sediment introduced to these lakes, save only local runoff that contributes little nutrient enrichment, but sustains these aquatic ecosystems. Many

chemical parameters in water have been typically below laboratory detection limits (MDLs) since formal baseline monitoring started in 2006[17].

4.3.2. Temporal and Spatial Trends

The full summary of 2018 water quality data is provided in **Appendix B1**. The Meadowbank project lakes (NF locations only) were screened against site-specific trigger and threshold values developed for the Meadowbank project lakes and Wally Lake. Many water quality parameters had concentrations that were routinely below laboratory MDLs, thus providing little insight into the assessment of mine-related changes to water quality. To streamline the interpretation process, a conservative three-step screening process was used to identify parameters for inclusion into the formal trend assessment (the results are summarized in **Table 4-2**):

- Overall Detection Frequency – Only those water quality parameters that exceeded MDLs in at least 10% of the samples were included in this discussion. Because the project lakes are ultra-oligotrophic, it is normal for many parameters to routinely be below MDLs. In 2018, just over half (56%) of parameters measured exceeded MDLs at least 10% of the time. These parameters are included in this discussion.
- Control-Impact Detection Frequency Comparison – To avoid screening out infrequently detected parameters that were detected more often in association with mining activities, the proportion of samples exceeding MDLs between "control" and "impact" samples were compared. The intent of this screen was to identify parameters with <10% detection frequency (i.e., those screened out above) for which there were detection frequency changes potentially associated with mining activity (i.e., where the proportion of detected values increased by 0.1 or more). No parameters were added back into the trend assessment based on this second screening level.
- Apparent Detection Pattern Matching Mining Activity – As a further step to avoid screening out potentially important parameters, trend plots for infrequently detected parameters were used to visually identify parameters with measured values associated with periods/locations of known mining activities (see **Table 1-1**). Where such patterns were observed or where parameters were measured at greater than 5-times the MDL at near-field sampling areas in at least one event, these parameters were added back into the trend assessment process. Given that no such patterns have been observed since 2008 East Dike

[17] While formal baseline water quality monitoring started in 2006, reconnaissance baseline monitoring started in the mid-1990s and served as the foundation for designing the formal monitoring program.

construction and no major activities have taken place on site in 2018, no parameters were added back into the trend assessment process based on this screen.

Water chemistry parameters that were retained in the analysis are shown in **Table 4-2.** Monitoring results showing spatial (all NF, MF, FF, and REF areas) and temporal (all monitoring years) for surface water (samples collected from a depth of 3 meters) for retained parameters are shown in **Figure 4-14** to **Figure 4-53**. The red dashed line in each of these water chemistry figures is the trigger value specific to the parameter and area – there are different trigger values for Wally Lake. Parameters not retained for the trend assessment have no spatial or temporal trends related to mining activities or natural variability and were excluded from further consideration. For completeness and transparency, plots for these parameters are included in **Appendix B1**.

For each parameter/area that exceeded the trigger in 2018, formal statistical testing of the result was conducted using the BACI statistical model (one-tailed; looking for uni-directional changes [i.e., increases]). In this analysis, the model interaction term (or BACI effect term) represents the change at the test area in 2018 ("After" period) relative to baseline ("Before" period) after accounting for natural temporal changes (i.e., temporal changes at the reference area). For simplicity, changes are noted "relative to baseline/reference" conditions.

Parameters where the yearly mean in 2018 exceeded the trigger values at the NF areas are shown in **Table 4-3;** the only new parameter/area combinations for NF areas in 2018 were bicarbonate and total alkalinity at TPE. Results of the BACI analysis for parameter/area combinations where the 2018 results were statistically different ($p<0.05$) are provided in **Table 4-4**. Conclusions from the 2018 BACI analysis in 2018 were largely the same as last year, namely, there were increases in conductivity, major ions, and other non-threshold parameters in the NF lakes relative to baseline/reference conditions. Context for these results from an aquatic ecosystem perspective is described below for each parameter (or parameter group):

- **Laboratory Conductivity/Hardness** – TPN, TPE, SP, and WAL showed an increase relative to baseline/reference conditions. This list of analytes and areas is identical to 2017 and consistent with previous reporting cycles. Conductivity is a composite variable that responds positively to increasing concentrations of ionic compounds (e.g., chlorides, sulphates, carbonates, sodium, magnesium, calcium, potassium and metallic ions). The observed change, therefore, is indicative of changes in its underlying compounds (e.g., see ionic compounds below for additional context).
- **Ionic Compounds (Calcium, Magnesium, Potassium, Sodium)** – TPN, TPE, SP, and WAL all showed an increase (relative to baseline/reference) for these major ions with the exception of Potassium at TPN and WAL, and Sodium at SP. Concentrations at these NF areas have

typically been <6 mg/L (calcium), <2 mg/L (magnesium), < 1.5 mg/L (sodium), and <1 mg/L (potassium). Slight increases of these ionic compounds in the Meadowbank study lakes in the ‘after’ period are unlikely to adversely affect biota. These major cations essential elements and all species of aquatic life, from algae to fish, have evolved to actively regulate their osmotic, ionic, and acid-base balance by uptake of ions from their surrounding environment (Martemyanov and Mavrin, 2012). Furthermore, adverse effects on primary producers and secondary consumers (e.g., zooplankton) are more commonly associated with deficiency rather than enrichment of major cations in oligotrophic freshwater lake environments (Alstad, et al., 1999). Calcium deficient waters are defined for some species algae at concentrations <10 mg Ca/L (Wetzel, 1983) and effects on zooplankton communities are more common in freshwater lakes that are calcium-depleted as a result of acidification and logging (Arnott et al., 2017).

- **TDS** – TPN, TPE, SP, and WAL showed an increase in TDS relative to baseline/reference conditions. The maximum reported concentration in 2018 was 51 mg/L at WAL in August, consistent with the magnitude of concentration reported in 2017. Weber-Scannell and Duffy (2007) reviewed TDS toxicity to aquatic life. While they recommend deriving ion-specific limits for aquatic life (i.e., rather than for TDS), none of the literature studies they compiled showed effects at TDS concentrations less than 250 mg/L and they report mean TDS in the world’s rivers of approximately 120 mg/L. There are no federal water quality guidelines for TDS in Canada or the US. In Alaska, TDS may not exceed 500 mg/L without a special permit and 1,000 mg/L at any time (ADEC, 2012). A TDS receiving environment benchmark 500 mg/L was adopted at Diavik (WLWB, 2013). Thus, these changes leading to TDS concentrations on the order of 15 to 50 mg/L are very low and do not pose risks to aquatic receptors.
- **Alkalinity** – SP and TPE showed an increase in bicarbonate and total alkalinity in 2018 relative to baseline/reference conditions. Bicarbonate (HCO_3-) comprised 100% of the total alkalinity fraction, typical of surface water with pH in the range of 6.5 to 9. Bicarbonate alkalinity at SP has consistently exceeded the trigger dating back to 2011, and in 2018 the mean concentration was 12.46 mg/L (as $CaCO_3$), similar to the concentration reported in 2017 of 11.0 mg/L and to the concentrations reported in 2015 of 11.5 mg/L and 2016 of 11.1 mg/L. The trigger value for both bicarbonate and total alkalinity is 8.5 mg/L. TPE exceeded the bicarbonate trigger in 2018 with a mean concentration of 8.65 mg/L. The results for TPE were very similar as those reported for 2017 with bicarbonate values just over the trigger values in the May samples before stabilizing below the triggers in later sampling events. However, in 2018 the mean concentration for all samples strayed just over the threshold value by 0.15 mg/L. From a potential effects perspective, alkalinity is a measure of the

buffering capacity of water (i.e., how much acid can be added without changing pH) and low values are typically of concern for aquatic life. For example, the working water quality guidelines for British Columbia (BC ENV, 2017) have three categories of sensitivity to acid inputs based on alkalinity: highly sensitive (< 10 mg/L), moderately sensitive (10 to 20 mg/L) and low sensitivity (>20 mg/L). Consequently, the temporal trend of slightly increasing alkalinity relative to baseline/reference conditions is unlikely to adversely affect biota at TPE or SP and would decrease their potential sensitivity to acidic inputs (e.g., low pH snow melt and rain).

In the absence of available effects-based thresholds, CREMP trigger values for these substances were set at the 95th percentile of baseline data (Azimuth, 2015b). While occasional threshold exceedances are expected (i.e., in the absence of any mine-related inputs, 5% of the samples would be expected to exceed the trigger), the trends described above are clearly mine-related. However, the BACI model results reported above only indicate that statistically significant changes have been detected relative to baseline/reference conditions. Furthermore, while these conditions have been observed for a number of years, it is important to note that they have been fairly stable over the last few years. As discussed above, available information suggests that the observed concentrations of these parameters are well below levels of concern.

Metals concentrations (total and dissolved) were consistently low or below their respective MDLs at the NF, MF, and FF locations in 2018 (**Appendix B1**). None of these parameters have ever exceeded trigger or threshold values in the formal BACI analysis. In 2018, the same metals were measured above laboratory detection limits (MDLs) as in previous years. This is important to note in relation to ongoing discharges to the receiving environment (e.g., discharge of East Dike seepage to Second Portage Lake).

The CREMP continues to detect changes in some general water quality parameters that appear to be related to mining activity. These changes are also reflected in higher concentrations of some parameters when compared to the model predictions in FEIS (Cumberland, 2005). The FEIS water quality predictions are estimates of change water quality in Third Portage Lake, Second Portage Lake, and Wally Lake assuming different mixing scenarios and loading estimates from water releases and dike leaching:

Third Portage Lake – the model for Third Portage Lake includes treated water release from the project in year’s 1 to 4 and long-term loading of metals from the Bay-Goose dike material. Two mixing scenarios (upper range [169 Mm3] and mid-range [92 Mm3] mixing) are evaluated for Third Portage Lake depending with and without dike leaching.

Second Portage Lake – The Second Portage Lake water quality model includes loading of parameters from the Third Portage and East dikes and inflow from Third Portage and Wally lakes. Changes in water quality in Second Portage Lake were modelled for the two different mixing scenarios of water releases into Third Portage Lake listed above.

Wally Lake – The water quality model for Wally incorporates long-term loadings from the Vault dike and effluent releases from the Vault Attenuation Pond.

The 2018 CREMP water quality data were screened against the model predictions for Third Portage Lake (**Table B1-2**), Second Portage Lake (**Table B1-3**), and Wally Lake (**Table B1-4**). The same list of parameters that exceed the Meadowbank trigger values typically exceed the concentrations predicted in the FEIS, namely ionic compounds (calcium and magnesium), hardness, and total alkalinity. Chloride, fluoride, nitrate, and sulphate also exceed the FEIS predictions for Third Portage Lake, Second Portage Lake, and Wally Lake in at least one sample. Most metals are below the predicted concentrations for Third Portage Lake (**Table B1-2**), Second Portage Lake (**Table B1-3**), and Wally Lake (**Table B1-4**) except for silicon (all three lakes), strontium (Third Portage Lake) and isolated instances of aluminum, copper, iron, manganese, and silver. Strontium consistently exceeded the model predictions for Third Portage Lake, but importantly did not exceed the trigger (95th percentile of baseline) indicating current strontium concentrations are representative of pre-development conditions.

At the time the FEIS was issued in 2005, the CWQG for cadmium was lower than the MDL for the baseline data. A thorough review of the ecological significance of the predicted cadmium concentrations was presented in the FEIS, and the probability of cadmium causing toxicity was considered "extremely low" (Cumberland, 2005). Arsenic was also predicted to exceed the CWQGs in Wally Lake. Similar to cadmium, the MDL for arsenic was equal to the guideline (i.e., 0.005 mg/L). The models were considered conservative because the MDLs were used as the baseline concentrations. The MDLs for arsenic and cadmium in the 2018 data are 0.0001 mg/L and 0.000005 mg/L, respectively. All of the samples collected in 2018 from Third Portage, Second Portage, and Wally Lakes were below the MDL for cadmium, as was the case in 2017 (**Figure B1-9**). In the case of arsenic, the concentrations are below the trigger values applicable to Meadowbank project lakes and WAL, and over an order of magnitude lower than the CCME water quality guideline of 0.005 mg/L in all samples. Overall, the FEIS predicted the magnitude of potential effect on water quality in each of the lakes as "low" (see **Section 2.4.1** for more details on the decision criteria for effect magnitude). It is important to point out that none of the above parameters that exceeded the trigger values or FEIS model predictions in 2018 have trigger values that were set in the context of effects-based threshold values (e.g., CCME water quality guidelines). Thus, CREMP water quality results are consistent with the "low" significance (i.e., <1x CCME WQG) rating applied to model predictions in the FEIS (Cumberland, 2005).

Pursuant to the new assessment strategy for MF and FF areas outlined in the *CREMP: 2015 Plan Update* (Azimuth, 2015b), formal analysis of the trigger/threshold exceedances in 2018 was applied to the decision criteria outlined in **Section 2.2.3** to determine the level of effort and frequency of sampling required at the MF and FF areas in 2018. The assessment strategy uses the water quality assessment results from current year (in this case 2018) to inform sampling at MF and FF areas the following year (i.e., 2019). The data were analyzed starting from the “Year +1” step of the flow chart where results from the NF areas are used to inform sampling at both MF and FF locations in 2018 (**Table 4-5**).

Trigger/threshold screening results are presented in **Table 4-5** according to their corresponding degree of change (i.e., no trigger exceedance, minor changes, moderate changes, and major changes). The outcome of the assessment for sampling at NF, MF and FF areas in 2018 is summarized below:

Near-field (TPE, TPN, SP, and WAL) – Trigger exceedances were documented for parameters without effects-based thresholds (e.g., conductivity, hardness, and cations). The full program will be completed at the NF locations in 2018 as well as at both reference areas (INUG and PDL).

Mid-field and Far-field (TE, TPS, and TEFF) – One through-ice sampling event was completed at the MF and FF areas in 2018. Some parameters without effects-based thresholds exceeded trigger values at TPS, TE, and TEFF in the May 2018 samples. All samples for metals were below their respective trigger values in 2018 with the exception of one dissolved chromium result at TPS-60 and one dissolved copper result at TPS-59. The chromium result was flagged as anomalous and has been removed from the analysis (see **Appendix A** for QA/QC review). The dissolved copper concentration was 0.0013 mg/L which is slightly over the trigger value of 0.00119 mg/L; however, the total copper values were below the MDLs for both TPS samples. Additional sampling during the open water period in 2018 was deemed unnecessary. Formal BACI analysis of the results was not completed given the new sampling and analysis framework. Given there were no trigger exceedances for parameters with effects-based thresholds at the NF areas in 2018, a minimum of one (but ideally two) through-ice sampling events at the MF and FF areas are recommended in 2019 to verify there are no exceedances of effects-based thresholds. No other sampling (e.g., sediment chemistry or benthic invertebrate community) is required at MF and FF areas in 2019.

4.4. Phytoplankton Community

4.4.1. General Observations

The diversity in types and sizes of phytoplankton is large and their abundance is great, typically exceeding 1 million individuals per litre with a total biomass of approximately 200 mg/m^3 in summer. Six major taxonomic groups of phytoplankton are present in the study lakes, namely blue-green algae (Cyanophyta), green algae (Chlorophyta), golden-brown algae (Chrysophyta), Diatoms, Cryptophytes and Dinoflagellates. Chrysophytes (golden-brown algae) are small, usually unicellular phytoplankton that are consistently the most abundant taxonomic group in the Meadowbank area lakes. Chrysophytes also dominate phytoplankton biomass in all project lakes, typically representing 65% or more of total phytoplankton biomass in summer samples, with smaller proportions (usually <10% each) from the other five major groups. The dominant chrysophyte genera for the Meadowbank lakes are *Chrysococcus, Kephyrion, Chrysochromulina, Dinobryon* and *Chrysolkos*. Dominant genera for the other groups were Oocystis for chlorophytes, Planktolyngbya for cyanophytes, Cyclotella for diatoms, *Rhodomonas* and *Cryptomonas* for cryptophytes, and *Gymnodinium* and *Peridinium* for dinoflagellates (Azimuth, 2012a, 2011b, 2010a, 2009c, 2008a, and 2008b).

Mean phytoplankton biomass in the Meadowbank area lakes typically ranges from 100 to 250 mg/m^3 during summer with diminishing biomass in fall through winter. This range in biomass is typical for oligotrophic, central Arctic Canadian lakes. Biomass estimates from lakes sampled in the 1980's in the Kiggavik area generally ranged between 100 and 300 mg/m^3 (McKee et al., 1989). Other studies on arctic lake phytoplankton communities have reported similar ranges of phytoplankton biomass at Snap Lake (266 mg/m^3; De Beers, 2002), Char Lake (166 mg/m^3, Kalff et al., 1975), and Spring Lake (120 mg/m^3, Welch et al., 1989).

4.4.2. Temporal and Spatial Trend Interpretation

The approach to identify potential mine-related impacts involves visually searching for general temporal-spatial patterns that might be associated with mine-related activities (see **Table 1-1** for details), augmented by statistical analyses of 2018 data to test for changes relative to baseline/reference conditions using the BACI model (see **Section 2.4.3** for details).

The primary metrics used in the assessment were chlorophyll-a concentration (a surrogate for overall primary productivity), total biomass (mg/m^3), relative biomass of major taxonomic groups, and species richness (total # species). Biomass, and not abundance, was examined because the two tend to be reasonably well correlated and ultimately, biomass is a much better approximation of actual lake productivity or food available to zooplankton. The BACI statistical testing focused on total biomass and species richness as these reflect ecologically relevant aspects of the phytoplankton community (i.e., total mass of community and community composition, respectively); trigger and threshold effect sizes are 20% and 50%, respectively.

The expected response patterns in phytoplankton biomass and species richness is dictated by the nature of the physical and/or chemical changes caused by mine-related activities. For example, dike construction or dewatering may introduce turbidity, leading to a reduction in phytoplankton biomass/diversity. In contrast, introduction of other substances such as nitrogen nutrients associated with blasting by-products could increase primary production, so we are looking for both reductions and increases (i.e., two-tailed statistical tests) in phytoplankton-related metrics coinciding with mining activities (i.e., focusing primarily on data for SP, TPE, TPN, and WAL).

One consideration with phytoplankton data is the high natural variability of control data. This potentially confounding “noise” effect can make it difficult to identify mining-related influences or “signals” at impact areas, unless the latter are quite large.

Density and biomass results for phytoplankton samples collected from the Meadowbank study lakes are provided in **Appendix D1**. The 2012 CREMP (Azimuth, 2013) provides a detailed description of historical trends in phytoplankton-related metrics; this report emphasizes results for 2018 (but retains the historical context by showing the results of all monitoring years). Trend data for chlorophyll-a, total biomass, major taxa composition, and species richness are presented in **Figure 4-54** to **Figure 4-58**. Plots for all other phytoplankton metrics are presented in **Appendix D1**. The results for the BACI model statistical tests of the 2018 results against baseline/reference conditions for total biomass and species richness are provided in **Table 4-6**; key results are described below:

Chlorophyll-a – Concentrations in the reference area samples typically ranged between 0.2 and 0.7 µg/L in summer months, reflecting the oligotrophic, nutrient poor condition of these lakes; a trend that has not changed over time. The seasonal pattern of chlorophyll-a concentrations among reference and exposure areas was similar in 2018, with higher concentrations observed at all locations during the late-summer event in September relative to earlier July and August open-water events, and to March and May through-ice events. The highest chlorophyll-a concentrations of all exposure areas in 2018 were at WAL, up to 1.4 µg/L in the October event. This trend of higher chlorophyll-a levels at WAL, and also to a lesser extent at TPN, relative to other sampling areas, has been consistent from 2015 to 2018. With the exception of an August peak in 2011 at TPN, seasonal peaks in chlorophyll-a were not as high at TPN and WAL prior to 2015. But overall, despite some variability in timing and magnitude of peak concentrations, chlorophyll-a concentrations have typically remained less than 1 µg/L since 2006 (**Figure 4-54**), which is consistent with oligotrophic conditions (Kasprzak et al. 2008).

Total Biomass – Biomass results followed the same seasonal trends as previous years with higher biomass reported in the summer months (July to September) compared to early spring. Winter under-ice biomass is naturally very low at all locations in all years it has been measured, and the same pattern was noted in 2018; biomass typically less than approximately 50 mg/m^3 in the May samples (**Figure 4-55**).

Peak summer biomass estimates at INUG were between 129 and 230 mg/m^3 which was higher than the 2017 peaks between 130 and 160 mg/m^3. In contrast, phytoplankton biomass PDL peaked around 139 mg/m^3 in September which was less than the 250 to 320 mg/m^3 in July 2017. Overall, these results are consistent with the range observed in previous years for the reference areas (**Figure 4-55**). Biomass at NF areas in 2018 was measured at levels generally between 120 and 259 mg/m^3 from July through the latest phytoplankton sampling event in 2018, which was mid-September for NF exposure areas (i.e., sampling periods didn't capture expected fall/winter drop-offs in phytoplankton biomass). The peak biomass at the NF areas (150 to 259 mg/m^3) was lower compared to 2017 (upwards of 500 mg/m^3). WAL in particular had lower biomass in 2018, peaking at up to 259 mg/m^3 in July compared to 500 mg/m^3 in July 2017. Other NF exposure areas include TPE, TPN and SP also had lower peak biomass for 2018 than in 2017.

The BACI analysis shows apparent increases ranging from 39% to 58% at the NF areas in 2018 relative to baseline/reference (INUG) conditions; the apparent increases were statistically significant ($p<0.1$) at WAL (56% increase) (**Table 4-6**). The apparent increase was primarily due divergent patterns of lower biomass at INUG in 2018 and slightly elevated biomass at TPN, TPE, SP, and WAL in 2018. For example, mean biomass during the open water season at INUG and TPE prior to mining were 218 and 167 mg/m3, respectively. In the 2018 open water season, INUG was down by 34% and TPE up by 23%. The BACI model assumes that trends occurring at the reference area also occur at the exposure area (e.g., responses due to regional climatic conditions), so the opposite responses seen in 2018 contribute to a large apparent effect. Unlike the cases where water quality parameters have clearly increased due to mining activity (**Section 4.3**), the historical results for the NF areas (**Figure 4-55**) do not show obvious visual signs of temporal increases for individual areas. While changes in phytoplankton biomass in 2018 exceeded trigger (>20% effect; SP) and threshold (>50% effect; SP and WAL) values, it is hard to determine in a single year whether these changes are related to mining. For example, while the apparent response at SP (58% increase) is coincident with mining-related discharges, TPN's 49% increase, TPE's 39% increase, and WAL's 56% increase in biomass in 2018 occurred despite no effluent discharging into those areas in 2018. This suggests that natural variability may be an important driver of the observed trends.

Major Taxa Composition – Chrysophytes tend to dominate in all open-water months, a pattern that has been consistent since monitoring began in 2006 (**Figure 4-56**).

Taxa Richness – Seasonal profiles in taxa richness were similar in shape to total biomass, with an increase from low diversity in under-ice months (INUG; 12 to 14 taxa) to peak diversity of between approximately 30 and 40 taxa during the open water season (**Appendix D1**). The seasonal pattern of taxa richness at the exposure areas was similar to the reference areas and consistent with previous years (**Figure 4-58**). A statistically significant increase (29%; p=0.03) in taxa richness was noted at TPN in 2018 relative to baseline/reference conditions, and the effect size was above the 20% trigger level (**Table 4-6**). It is important to note that the effect at TPN in 2018 was an increase in taxa richness (i.e., species present) relative to baseline/reference conditions rather than a decrease.

The phytoplankton community taxa biomass and taxa richness data from 2018 are generally similar to previous years and largely appear within the range of historical baseline/reference conditions. That said, statistically significant (P<0.1) changes were detected above triggers (TPN: +29% in taxa richness) or thresholds (WAL: +56% in biomass). However, ascribing causality for these statistically significant effects from the BACI model is more difficult. As discussed above for total biomass, there is evidence that natural variability might be driving these effects. Specifically, neither TPN nor WAL received mine-related discharges in 2018 and much of the apparent changes at these NF areas can be attributed to lower results in 2018 at INUG rather than absolute gains at the individual areas. While the gradual changes in water quality observed over the years could have resulted in stimulated phytoplankton productivity, they do not explain the increases in biomass, and to a lesser extent taxa richness, seen in 2017 or 2018. Natural variability is the most plausible explanation for apparent increased biomass (relative to baseline years) at the NF areas in both years. Notwithstanding, this trend will continue to be watched closely in 2019 to verify whether future patterns are consistent with that conclusion or whether they provide stronger evidence of mine-related causality.

4.5. Sediment Chemistry

4.5.1. General Observations

Natural sedimentation rates are considered low, due to the headwater nature of the watersheds and the lack of any substantial riverine or tributary inflow. Thus, very little sediment is carried into the lakes besides what may erode off the nearby tundra during spring run-off or heavy rain events, or from dust deposition. There are, however, a number of mine-site activities that can generate dust and potentially increase the net deposition into project lakes.

Based on historical bulk sampling of sediment using grab samples, we have observed reasonably large, within-basin or within-lake differences in surface sediment (i.e., top 3 – 5 cm) concentrations for a variety of metals, indicative of natural spatial heterogeneity driven by localized mineralization. There are a number of processes that can affect the pattern of metals distribution to sediments, including differential deposition of different grain size materials according to wind direction and speed, water depth, water currents, basin morphometry, bioturbation (i.e., vertical mixing of sediment by burrowing insect larvae) and patchy, heterogeneous distribution of metals in mineralized areas. Grain size has a very large influence on metals concentrations – with coarse grain size (i.e., sandier) typically correlating with lower metals concentrations. As such, our sediment programs target low energy, depositional areas that are dominated by silt/clay sediment in areas of similar depth (6 – 10 m), where grain size tends to be finer and more consistent.

Sediment chemistry samples have been collected using grab samplers (targeting top 3 - 5 cm) or coring devices (targeting top 1.5 cm). Grab samples are used every year to characterize the chemical and physical conditions of sediments paired with the benthic invertebrate community samples. While grab samples can provide insights into temporal changes in sediment chemistry, core samples are a more sensitive tool and are used in the CREMP to formally test for changes in sediment chemistry related to mining. Core samples are collected every three years to match the timing of EEM studies required under the *Metal and Diamond Mining Effluent Regulations*. Below is an overview of the various sediment coring programs at Meadowbank dating back to baseline sampling in 2008:

- 2008. Baseline coring was conducted in July 2008 prior to onset of East Dike construction to characterize baseline surface metals concentrations at all monitoring areas.
- 2009. The 2009 coring program was implemented to monitor potential changes to surface sediment chemistry that may have occurred as a result of the East Dike sedimentation event in August 2008. The 2009 study was conducted only at SP, TE, TPE, and INUG. TPE and INUG were used as the reference areas for SP and TE.
- 2010 to 2013. The 2010 to 2013 sediment grab sampling programs covered all NF, MF, and FF Meadowbank study lakes as well as the reference areas INUG and PDL. Sediment coring was completed as part of the 2012 program.
- 2014. The 2014 program covered all Meadowbank study lakes sampling areas and reference areas. Note that the 2014 program was advanced a year ahead to align with EEM program. Additional sampling was completed at TPE in 2014 to help assess whether the apparent changes in sediment chromium concentrations were related to spatially biased sampling or were a real temporal trend. Two zones in TPE were targeted for coring: the zone sampled

initially in 2008 and 2009 (prior to dike construction; TPE-B) and the zone sampled in 2010 (TPE). Results from this analysis helped inform the design of the targeted chromium bioavailability study conducted at TPE in 2015.

- 2015. The routine 2015 sediment sampling program was limited to the NF study lakes in accordance with the new approach outlined in the *CREMP: 2015 Plan Update* (Azimuth, 2015b). In addition to routine sampling, a targeted bioavailability and toxicity testing program was completed on sediments from TPE to provide more information on whether the apparent increase in chromium concentrations is adversely affecting the benthic invertebrate community. Sediment grab samples were collected from two zones in TPE and from the reference areas. Samples were analyzed for total metals and other conventional parameters as per the routine CREMP program, as well as sequential extraction testing to determine the bioavailability of sediment chromium. Bulk sediment was sent to a toxicity testing laboratory where two tests were run using *Chironomus dilutus* and *Hyalella azteca*.
- 2016. Sediment sampling in 2016 was limited to grab sampling at the Meadowbank study lakes, synoptic with the benthic invertebrate community sampling locations.
- 2017. Sediment grab (n=5) and core (n=10) sampling was completed at all of the Meadowbank project lakes. Core and grab samples were spaced throughout each basin. Grab for chemistry and benthic invertebrates were collected at the same location. Core samples were opportunistically collected from some of the grab sampling locations. The remaining replicates were spaced throughout the basin in areas with the targeted depth and substrate composition.
- 2018. Sediment grab sampling at the Meadowbank study lakes synoptic with the benthic invertebrate community sampling locations. Targeted studies were conducted at TPE and WAL to follow up on recommendations in the 2017 CREMP (Azimuth, 2018c). The 2017 CREMP study found that chromium concentrations in the sediments at TPE and the arsenic concentrations at WAL appeared elevated compared to pre-development baseline concentrations. Sediment coring (10 replicates per location[18]) was conducted to verify the 2017 results and toxicity testing (**Section 4.6.3**) was conducted according to the same method used in 2018.

4.5.2. Temporal and Spatial Trend Interpretation

Tabulated 2018 sediment chemistry results for the grab and core samples are presented in **Appendix C**. Concentrations of individual metals have been plotted in **Figure 4-60** to **Figure 4-67**.

[18] A "replicate" is a discrete core sample following the standard operating procedure (SOP) in Azimuth 2015b.

Metals concentrations are shown by area/basin for the different sampling methods (grab [data points] vs core samples [box and whisker plots]). The red dashed line in each of sediment metals figures is the trigger value specific to the parameter and area (i.e., Meadowbank lakes and Wally Lake each have their own trigger values as of 2017). The box and whisker plots illustrate the statistical distribution of core samples within each area. Data interpretation for the box and whisker plots is as follows:

- The horizontal line inside the box represents the median concentration
- The upper and lower margins of the box represent the upper (75th) and lower (25th) percentile concentrations, respectively (the "interquartile" range)
- The vertical lines represent maximum and/or minimum concentrations (provided at least one value falls outside the box but within 1.5 times the interquartile range)
- 'x's that occur beyond the maximum or minimum lines represent concentrations that are greater than 1.5 times the interquartile distance and indicate 'outlier' concentrations that are real, but don't fit within the distribution of the rest of the data, for whatever reason.

Grab samples for sediment chemistry were collected synoptically with benthos community samples at TPE, TPN, SP, WAL, INUG, and PDL and were screened against the trigger and threshold values (**Appendix C** and **Figure 4-60** to **Figure 4-67**). Results for Wally Lake and TPE, which were also the focus of a targeted sediment coring study, are discussed in subsections below. Chromium concentrations at the reference area PDL exceeded the Meadowbank triggers in 2018 as in previous years (**Figure 4-63**). The only analyte exceeding trigger or threshold values at the NF areas was zinc at SP (**Figure 4-67**). While zinc concentrations at SP in 2018 ranged from 118 mg/L to 128 mg/L (trigger = 114.2 mg/kg; threshold = 123 mg/kg), they were within the range of baseline concentrations observed between 2006 and 2008. The variable historical pattern for SP suggests the influence of small-scale, natural spatial heterogeneity in zinc rather than mining-related changes in sediment quality.

Coring was completed in 2018 at TPE and WAL to follow-up on potentially elevated chromium (TPE) and arsenic (WAL) noted in 2017 (Azimuth, 2018c). Comparison to triggers and statistical analysis (before-after assessment) of concentration changes over time are presented in **Table 4-7** and **Table 4-8**, respectively. Below is a summary of the 2018 sediment chemistry results (coring and grab samples) for TPE and WAL:

- **TPE** – Mean sediment chromium concentrations at TPE exceeded the trigger value in 2018 (mean value = 149.9 mg/kg; trigger value = 135 mg/kg; **Table 4-7**), but were substantially lower than 2017 (204 mg/kg). Chromium concentrations at TPE consistently trended higher between the onset of the mine development in TPE in 2009 (i.e., change in status from "before" to "after") and 2013 (**Figure 4-63**), likely related to use of ultramafic rock for dike construction. The pattern since 2013 has been variable, suggesting the influence of spatial heterogeneity. While the "temporal" variability since 2013 makes it hard to be conclusive, it appears as though chromium concentrations may no longer be increasing. The follow-up sediment coring program at TPE in 2018 highlights the importance of conducting confirmatory sampling as part of the adaptive management response plan to *verify* apparent trends in chemistry.

- **WAL** – Arsenic was the only parameter at WAL to exceed a trigger value in 2018 (**Table 4-7**). While the mean concentration in 2018 (46.6 mg/kg) was substantially lower relative to 2017 (62 mg/kg), the result still represented a statistically-significant change (~50% increase) relative to baseline coring results (**Table 4-8**). Notwithstanding, the pattern of results in the "after" years generally falls within the range observed during the baseline period (<2013) based on cores and grabs (**Figure 4-61**), suggesting the influence of spatial heterogeneity rather than a true mining-related change. This is corroborated by the results for chromium and lead, both of which had statistically-significant exceedances of their respective triggers in 2017 but were lower in 2018; concentrations of both metals in the "after" period remain consistent with the ranges observed during baseline based on core and grab samples (**Figure 4-63** and **Figure 4-65**). Thus, while these trends will continue to be closely monitored, natural spatial heterogeneity appears to be the most likely explanation for the observed temporal patterns.

4.6. Benthos Community

4.6.1. General Observations

The abundance and species composition of benthic invertebrates are strongly affected by water depth, substrate size and organic carbon. Other physical factors, such as water temperature, can influence larval development rates and ultimately timing of hatching for insect larvae. Consequently, even if sampling can be conducted simultaneously in all lakes (which is not practical), this would still not overcome differential timing of hatching of particular species between lakes. This is partly overcome in the CREMP by sampling during late fall, after the emergence of most groups, but is still a source of some variability.

Benthic invertebrate communities in the Meadowbank study lakes are characterized by relatively few taxa and low abundance. Abundance is generally less than 2,000 organisms/m^2 and is often less than 1,000 organisms/m^2 among both reference and exposure areas (e.g., **Figure 4-68**). Despite abundance generally being low at the study lakes, values above 5,000 organisms/m^2 are not uncommon and they have even exceeded 10,000 organisms/m^2 on occasion. Relatively large total benthic invertebrate abundance values were periodically observed in replicate samples collected prior to mine development (e.g., one replicate had 26,000 organism/m^2 at WAL in 2006) and in more recent sampling events (e.g., one replicate had 31,000 organism/m^2 at WAL in 2016). The high variability in total abundance within an area has also recently been observed at lakes sampled for the Whale Tail Pit project during the baseline period (i.e., the “before” period). Lake A76 had total abundance in 2017 ranging between 3,000 and >24,000 organisms/m^2 (Azimuth 2018a). Whale Tail Lake – South Basin also showed comparatively large variance in abundance in 2017 ranging from 1,800 to over 10,000 organisms/m^2. Abundance data for the Meadowbank study lakes between 2006 and 2018, as well as more recent baseline data from the Whale Tail Pit program, show there can be substantial natural spatial and temporal variability in abundance both among and within sampling areas.

Taxa richness typically ranged from 8 to 12 for most area/year combinations (**Figure 4-71**). Typical of most Arctic lakes, the benthic invertebrate community has been dominated by the aquatic larval stages of insects, especially chironomids (Family Chironomidae), both in terms of abundance and taxa richness (e.g., **Figure 4-69** and **Figure 4-72**). The next most abundant group was Mollusca (clams), particularly *Cyclocalyx* / *Neopisidium* genera of the family Sphaeriidae (fingernail clams). Oligochaete worms were also relatively common in the lake sediments; generally, at least one oligochaete taxon was present at most area/year combinations.

4.6.2. Temporal and Spatial Trend Interpretation

Benthic invertebrate abundance and richness results from the reference (INUG and PDL) and NF (TPE, TPN, SP, and WAL) Meadowbank study lakes in 2018 are provided in **Appendix E-1** by major taxa group (i.e., Insecta, Mollusca, Oligochaeta, and other taxa). Geometric means of total abundance and total richness for the entire data set dating back to 2006 are provided in **Table 4-9.**

Time-series plots showing abundance and richness endpoints are presented in **Figure 4-68** to **Figure 4-73**. Below are descriptions of the endpoints based on Environment Canada EEM guidance (2012):

- Total abundance – the number of individual organisms per m^2, this metric is a measure of community density.
- Total richness – the number of different taxa (identified to the lowest practical taxonomic level, usually species) per grab.
- Major taxa group abundance – similar to total abundance, but broken down by major taxa group.

- Major taxa group relative abundance – proportional abundance of each major taxa group.
- Major taxa group richness – similar to total richness, but broken down by major taxa group.
- Major taxa group relative richness – proportional richness of each major taxa group.

Other benthic invertebrate community results presented in **Appendix E1** but not discussed in detail include time-series plots of abundance and richness within each major taxa group, Simpson's Diversity and Bray-Curtis Index values.

The identification of potential mine-related impacts generally involved visually examining the data for spatial/temporal patterns that matched mine-related events. Visual examination of the data was further supported with statistical analyses of the 2018 data to test for changes relative to baseline/reference conditions using the BACI model (see **Section 2.4.3** for details). The BACI comparisons involved looking at longer-term trends (i.e., up to four-year trends) and focused only on benthic invertebrate total abundance and taxa richness. Details regarding historical trends (e.g., related to sedimentation events) were discussed in the 2011 CREMP (Azimuth, 2012a) and the 2011 EAS (Azimuth, 2012b). This report focuses on the 2018 results and trends over the last four years (i.e., dating back to 2015). As discussed in **Section 2.2.3**, MF (TPS and TE) and FF (TEFF) areas were not sampled in 2018. BACI model results for benthic invertebrate abundance and richness are presented in **Table 4-10** and **Table 4-11**, respectively. Key results are described below.

- **Total abundance** – INUG and PDL both had similar abundances in 2018 compared to 2017. INUG is the main reference area used for the BACI comparisons, so it is important to note that total abundance has been relatively high (for INUG) there over the last four years (**Table 4-9**). However, absolute abundance is generally lower at INUG relative to the NF areas, with maximum abundance of 2,100 organisms/m^2 (2016) relative to SP (2,796 in 2014), TPN (3,025 in 2015), TPE (5,556 in 2008), and WAL (14,253 in 2016).

  Abundances at TPN and WAL were higher than expected in 2018 based on baseline/reference conditions. The most notable change was for WAL (244% increase relative to baseline/reference conditions), although the result was not statistically significant. The main reason for the lack of statistical significance is the high natural variability seen at WAL through its long baseline period (2006 through 2012), when abundance ranged from 800 (2011) to 12,894 (2006) (**Table 4-9**). Thus, while abundances over the last three years have been much higher at WAL than at INUG, they still fall mainly within the range of results seen during the "before" period (except for the 14,253 organisms/m^2 seen in 2016) and are offset somewhat by the relatively high abundances seen at INUG over this period (**Figure 4-68**). Consequently, the apparent increases seen at

WAL in more recent years (and TPN in 2018) likely reflect the natural annual variability in benthic invertebrate abundance in this lake.

The only substantial decrease in abundance observed in recent years was at TPE, which showed a change relative to baseline/reference conditions of between -43% and -48% in each of the after periods tested (**Table 4-9**); results for the 2016-2018 and 2015-2018 after period groupings were statistically significant (**Table 4-10**). Interestingly, this result does not appear to match the temporal trends in abundance for TPE shown in **Figure 4-68**, which highlight that abundance at TPE has remained fairly constant over the last six years of operations and remain consistent with baseline results. The *apparent* reduction in abundance at TPE in the BACI analysis is due to the combined effect of two aspects of the benthos data for TPE and INUG. First, abundance measured at TPE during the baseline period (2006 and 2008[19]) was particularly high (two of the three highest abundances measured at TPE occurred during baseline; **Table 4-9**), making mean abundance for the baseline period higher compared to more recent data from the 2015 to 2018 monitoring period. Second, as described above, abundance at INUG has increased slightly in compared to TPE over the past four years have been particularly high relative to previous years (**Table 4-9**). Thus, while the combined results of these two aspects led to the detection of an apparent reduction in benthic invertebrate abundance at TPE, that result is due to a relative (to INUG) rather than an absolute (at TPE) reduction. The BACI results, while important for identifying potential temporal changes in benthos metrics, need to be interpreted in the broader context of the absolute change in the benthos community over time. Overall, the abundance data do not suggest there are changes to benthos abundance in the NF areas that are attributable to mining activity.

- **Major taxa group abundance** – Insects were the dominant taxa group (generally over 60% relative abundance) followed by molluscs (roughly between 10-20% relative abundance) (**Figure 4-69** and **Figure 4-70**). While there were no apparent trends in composition changes related to mining, it is notable that most peaks (or valleys) in total abundance over the years appear to be driven by changes in abundance of insects (predominantly chironomids). Notable examples of this are WAL in 2006 and 2016, TPE in 2008, or TPS in 2015.
- **Taxa richness** – Taxa richness in 2018 was generally similar to other sampling years (**Figure 4-71**). Taxa numbers averaged between 6 (PDL) and 15 taxa (WAL) in 2018 (**Table 4-9**). The number of taxa at PDL decreased from 10 in 2017 to 6 in 2018. For other areas the number

[19] Two of the three highest reported geometric means for abundance at TPE occurred in 2006 and 2008. By comparison, 2007 was the second lowest reported since 2006.

of taxa were the same with the exception of TPN (change from 12 in 2017 to 11 in 2018) and WAL (change from 13 in 2017 to 15 in 2018). 2018 taxa richness was within range of richness observed over the duration of sampling years. The BACI analysis showed only slightly negative to positive effect sizes at all areas for 2018 and onwards; there were no statistically significant decreases in richness at NF areas in 2018 or the longer term 2, 3 and 4-yr after periods (**Table 4-11**). Despite some within-year variability in taxa richness, the NF areas show either stable or slightly increasing taxa richness.

- **Major taxa group richness** – Insects were dominant in terms of absolute and proportional richness (generally between five to ten taxa), followed by molluscs (~one to three taxa) (**Figure 4-72** and **Figure 4-73**). There were no apparent trends in composition related to mining.

The benthic invertebrate metrics (total abundance and taxa richness) for the NF and reference areas were generally within the range reported for previous years. While the BACI analysis detected decreased abundance at TPE relative to INUG in the past four years, the differences are primarily driven by increased abundance at INUG, while abundance at TPE has been relatively stable. Importantly, the diversity of the benthic invertebrate community at TPE is consistent with previous CREMP years, indicating the benthic community at TPE remains functionally diverse. In summary, no mine-related effects to the benthic invertebrate communities in the Meadowbank project lakes were observed in 2018.

4.6.3. Sediment Metals Bioavailability Study Results

Toxicity testing of sediments from TPE and WAL was conducted using two standard benthic invertebrate test species (larval midge [*Chironomus dilutus*] and amphipod [*Hyalella azteca*]). The toxicity test results are another line of evidence used to determine if current concentrations of metals at TPE and WAL pose unacceptable risks to benthos. Sediments from INUG and PDL were used as "field control" treatments along with the laboratory controls to determine if there were statistically significantly differences in survival or growth for lab organisms exposed to sediment from TPE or WAL.

Endpoints for both toxicity tests are growth and survival. *C. dilutus* is an infaunal species that lives and forages in the sediment during the larval stage. *H. azteca* is an epibenthic species that lives at the sediment-water interface. Of the two species, *C. dilutus* is more ecologically relevant because of the dominance of chironomids in the benthos community throughout the Meadowbank project lakes. Amphipods are not reflected in the benthos community in the Meadowbank project lakes, and the toxicity testing results for this species were weighted lower than results from the chironomid test when assessing their ecological significance. Notwithstanding the absence of amphipods in these lakes, *H. azteca* is generally more sensitive to the effects of sediment contamination than *C. dilutus* and therefore provides a more conservative level of assessment of the potential for contaminant-related effects to benthos. From a site management perspective, the *H. azteca* test results serve as the equivalent of an "early warning trigger" for detecting changes in sediment chemistry before more ecologically significant effects to *C. dilutus* are detected. Thus, while results of the *H. Azteca* test are weighted lower than those of the *C. dilutus* test when assessing risks to the local benthic community, moderate to high severity effects (e.g., effects to survival) in the amphipod test would likely warrant follow-up to better understand the nature of the situation (e.g., Does it represent a change in bioavailability that could ultimately affect chironomids?).

A two-step process was used to assess survival and growth in the exposure area treatments. The first step involved analyzing the survival and growth data to determine if there were statistically significant differences ($\alpha = 0.05$) between the exposure (TPE and WAL) and control groups (lab, INUG, and PDL). If the null hypothesis was rejected (i.e., significant difference detected between control and exposure treatment), the second step in the assessment involved calculating the % change relative to the pooled field data from INUG and PDL. The ecological significance of the % change for a given test / treatment was evaluated using the following framework:

- Negligible effect: < 10% reduction in mean growth or survival
- Low effect: 10 to 20% reduction in mean growth or survival
- Moderate effect: 20 to 50% reduction in mean growth or survival
- High (severe) effect: > 50% reduction in mean growth or survival

The toxicity test methods and results from Nautilus are provided in **Appendix G**. Survival and growth (i.e., organism dry weight) results for *C. dilutus* and *H. azteca* are shown in **Figure 4-74** and **Figure 4-75**, respectively, for each species. Toxicity testing was previously conducted at TPE in 2015, and the results from that year's tests are also shown in the plots for each species to provide temporal context for the results.

Third Portage Lake – East Basin

Chironomid Survival and Growth – No difference was observed in chironomid survival at TPE compared to the lab or field control groups in 2018 (**Table 4-12**). Survival was above 80% in all five replicates from TPE in 2018, similar to the results from 2015 (**Figure 4-74**). Significant differences in growth for the TPE treatment were observed compared the field control groups but not when compared to the laboratory control. The implications of these results are assessed further in **Section 4.6.4** within a weight-of-evidence framework.

Amphipod Survival and Growth– Significant differences in survival and growth were observed for *H. azteca* exposed to sediment from TPE compare to laboratory and field control treatments. Of the five replicate samples tested, three replicates had complete 100% mortality. The other two replicate samples had 40% and 100% survival (**Table 4-13**). The laboratory report indicated water quality was good throughout the test and the QA/QC assessment met the conditions outlined in the protocol. The effect on amphipod survival in 2018 was more apparent than the 2015 amphipod test results from TPE. In 2015, complete mortality was observed in 2 of 10 replicate samples from TPE[20], but across the remaining 8 replicates, average amphipod survival was 83% (**Figure 4-75**). The wide-range in survival at TPE is surprising given the consistency in sediment chemistry reported among the five grab samples in 2018. Chromium concentrations in the grab samples from TPE were less than the trigger value (135 mg/kg) in all five replicates (**Figure 4-63**). The results are further confounded by the higher concentrations of chromium reported in sediment from the reference area PDL. Bulk sediment concentrations are evidently not a good predictor of toxicity for this species. The implications of these results are assessed further in **Section 4.6.4** within a weight-of-evidence framework.

Wally Lake

No statistically significant differences were observed in the WAL sediment treatment compared to the laboratory or field control groups **Figure 4-74** [*C. dilutus*]; **Figure 4-75** [*H. azteca*]). Coupled with the lower sediment arsenic concentrations observed in the 2018 coring results (i.e., which implied that local spatial heterogeneity, rather than an actual mining-related change, appeared responsible for last year's elevated sediment arsenic concentrations at WAL; **Section 4.5.2**) and the lack of adverse effects seen in the benthic community at WAL (**Section 4.6.2**), these toxicity test results further demonstrate that current concentrations of metals are not adversely affecting the structure or function of the benthos community.

4.6.4. Weight-of-Evidence Assessment

Given the statistically-significant effects to larval midge (*C. dilutus*; reduced growth) and amphipods (*H. azteca*; reduced survival and growth) in the laboratory toxicity tests, a weight of evidence (WOE) approach was used to conduct an integrated assessment of sediment chemistry, metals bioavailability (sediment toxicity) and benthic invertebrate community results to determine whether there are unacceptable risks to the benthic community at TPE.

[20] The study design in 2015 split TPE into 2 sub-basins to assess potential small spatial scale differences in test organism survival and growth.

Chemistry – the increasing trend in sediment chromium observed at TPE since the onset of construction for the Bay Goose Dike appeared to stabilize in 2018 (grab and core data; **Figure 4-63**). Given the limited input of natural sedimentation in these headwater lakes, the variable results seen since 2014 suggest the influence of spatial heterogeneity (e.g., there is no other mechanism to explain the apparent decreases seen in 2016 and 2018). While chromium concentrations at TPE were fairly similar to the PDL reference lake (which has naturally elevated chromium) in 2018, both are much higher than the CCME Probable Effects Level (PEL; CCME 2002). Overall, uncertainty remains regarding sediment metal bioavailability at TPE despite the appearance of stabilizing chromium concentrations (discussed in the next section on Toxicity).

Toxicity – The two toxicity tests were evaluated as separate lines of evidence in the WOE assessment. Chironomids are ubiquitous in northern lakes, and therefore *C. dilutus* is a more ecologically relevant test species a than *H. azteca* for extrapolating effects in the lab to conclusions on the health of the benthos at TPE. Relative to the field control treatments (INUG and PDL), chironomids exposed to sediment from TPE exhibited a ~21% reduction in growth during the 10-d test. There was no difference in growth when TPE was compared to the lab control, implying the reference sediments were a better medium for growth than the laboratory control sediment. There was no adverse effect on survival.

There were significant reductions in amphipod survival (70%) and growth (40%) at TPE in the 14-d amphipod test relative to the field control groups. There was no apparent correlation between bulk sediment chromium concentrations and lower survival (and growth) among the various treatments (**Figure 4-76**), suggesting that bulk sediment chemistry are not accurately characterizing metals bioavailability. While effects to amphipods, which are not present in the benthic community in the Meadowbank study area lakes, may not be ecologically relevant for TPE, these test results provide insight into the range of responses for different species based on current conditions.

Benthos Community – a detailed discussion on the benthic invertebrate community results for TPE can be found in **Section 4.6.2**. While an apparent reduction in total abundance was identified in the BACI analyses, the results were considered a BACI artefact as abundance has been consistently trending within the baseline range (**Figure 4-68**). More importantly, there has also been no evidence of reduced taxa richness at TPE (**Figure 4-71**), which would typically be expected with metals-related impacts as sensitive species disappear. Taxa richness from 2015 to 2018 was at the upper end of the range reported since 2006 (**Table 4-9**).

Summary

Chromium concentrations at TPE, while exceeding the trigger, appear to have stabilized relative to the recent increasing temporal trend. Sediment toxicity testing, however, suggested that sediment metals may be more bioavailable in 2018 than the 2015 study found. The amphipod test, while less ecologically relevant to the Meadowbank region, showed substantial effects to survival that were not correlated to sediment chromium concentrations, suggesting that other exposure pathways (e.g., porewater) or stressors (e.g., physical or chemical) may be responsible for the toxicity seen in 2018. While there was some reduced growth seen in the chironomid test in 2018, there lack of effects to survival combined with the stable benthos community at TPE suggest that current concentrations of chromium or other metals at TPE are not currently posing risks to the TPE benthic community. That said, there are uncertainties regarding the exact cause of the observed effects to *H. azteca* survival in 2018 that warrant follow-up in 2019 to provide added assurance that bioavailability is not changing at TPE.

4.7. Meadowbank Tables and Figures

The tables and figures for the Meadowbank CREMP are provided in this section except for the large tabulated datasets and figures for parameters that are not included in the detailed analysis (see in-text references to appropriate Appendices). Subsections are provided for each of the CREMP components (e.g., limnology, water chemistry, phytoplankton, sediment chemistry, and benthos).

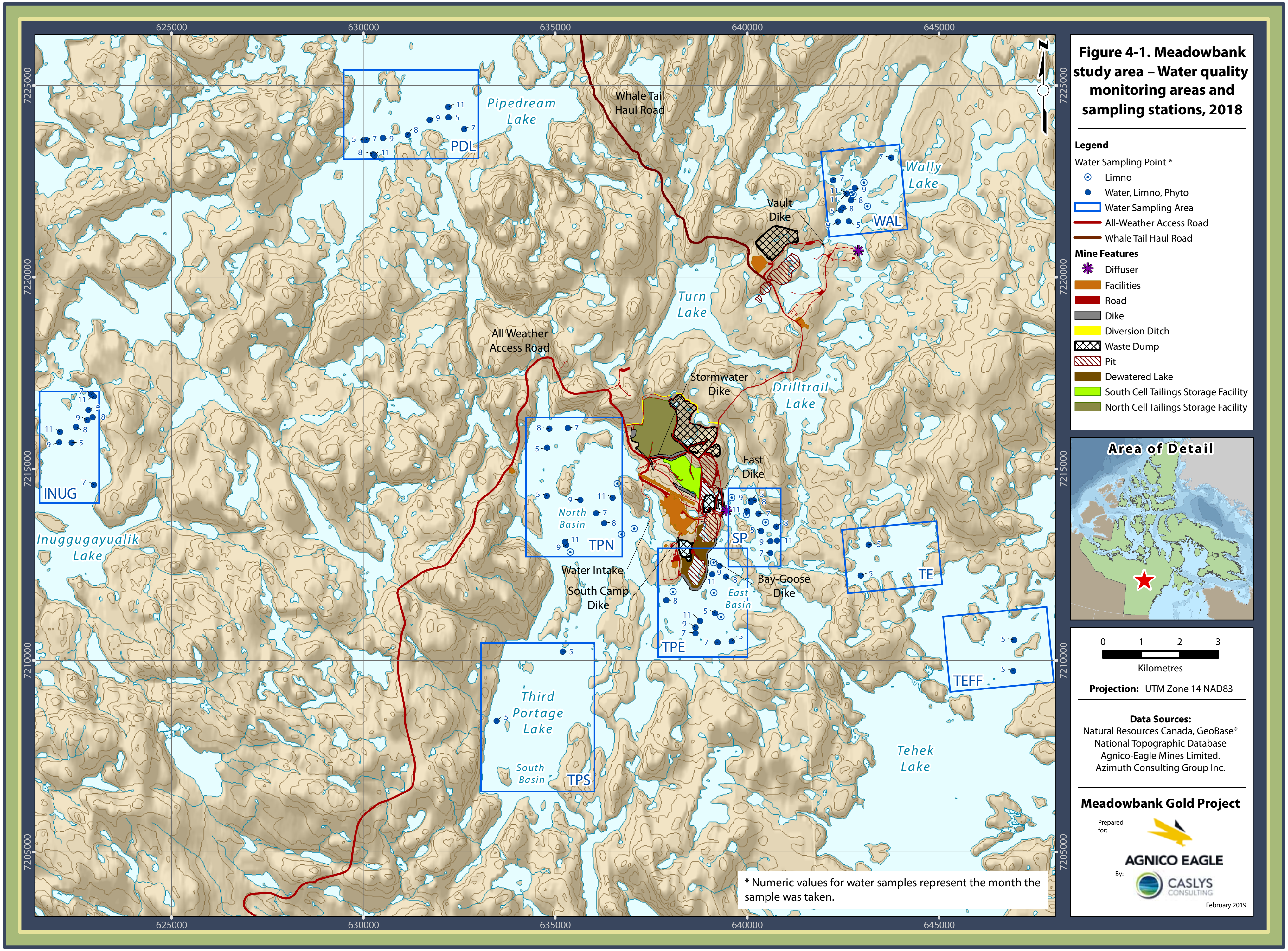


Figure 4-1. Meadowbank study area – Water quality monitoring areas and sampling stations, 2018

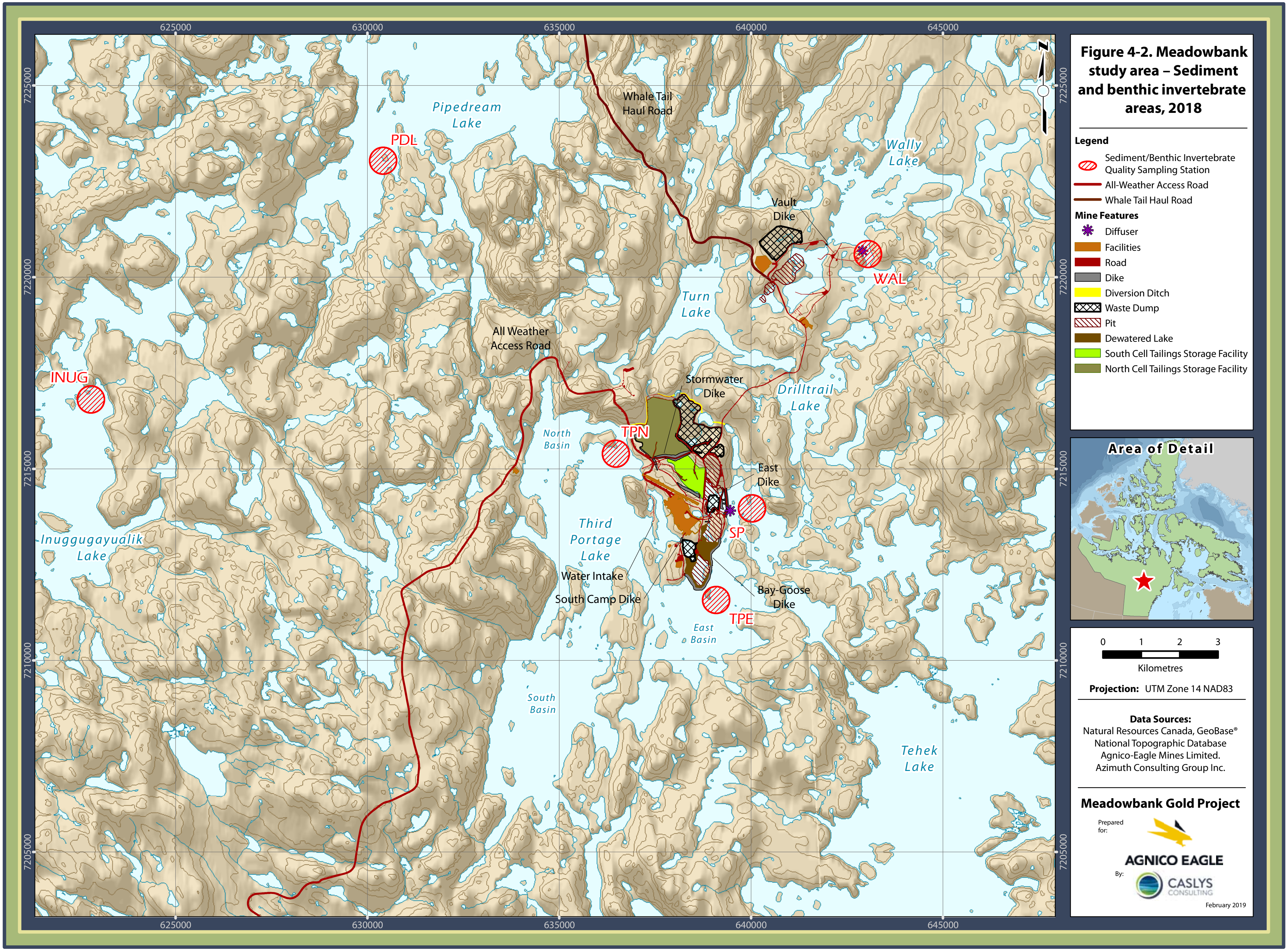


Figure 4-2. Meadowbank study area – Sediment and benthic invertebrate areas, 2018

Limnology Tables and Figures

Figure 4-3. Mean monthly field-measured temperature (°C) at 3 m depth from 2006 – 2018, Meadowbank project area lakes.

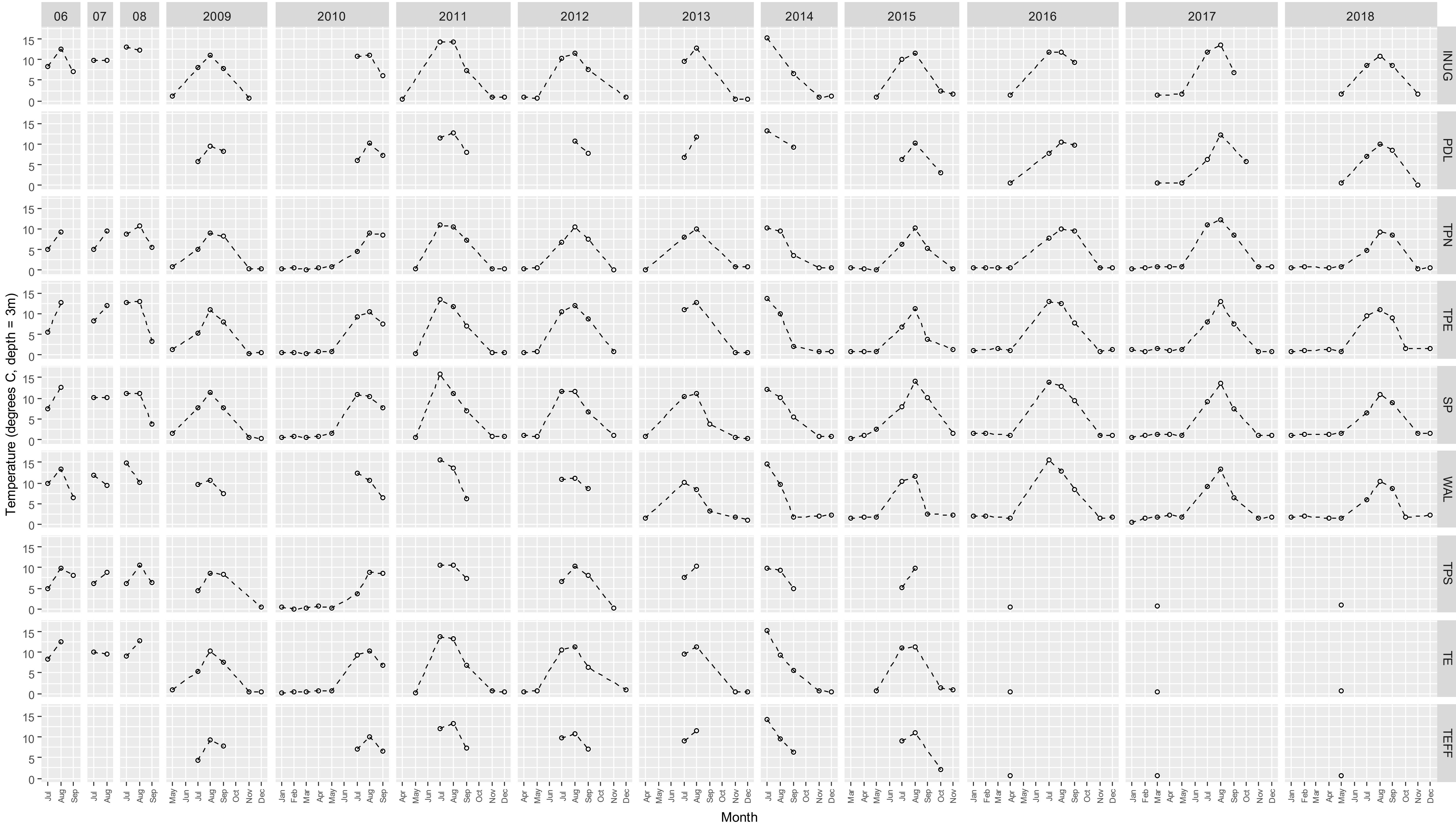


Figure 4-4. Meadowbank – Field-measured temperature, conductivity, and dissolved oxygen profiles, January 2018.

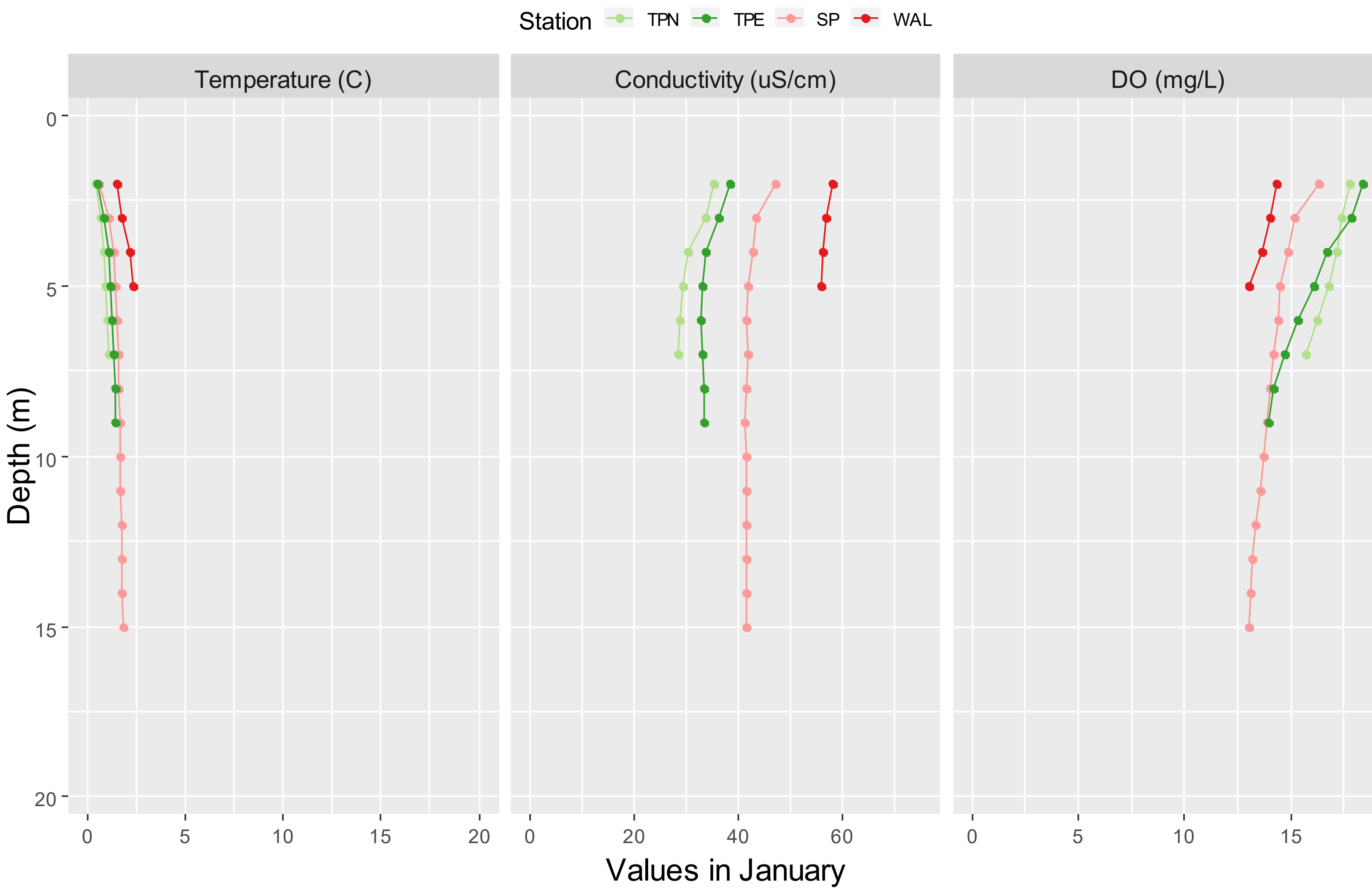


Figure 4-5. Meadowbank – Field-measured temperature, conductivity, and dissolved oxygen profiles, February 2018.

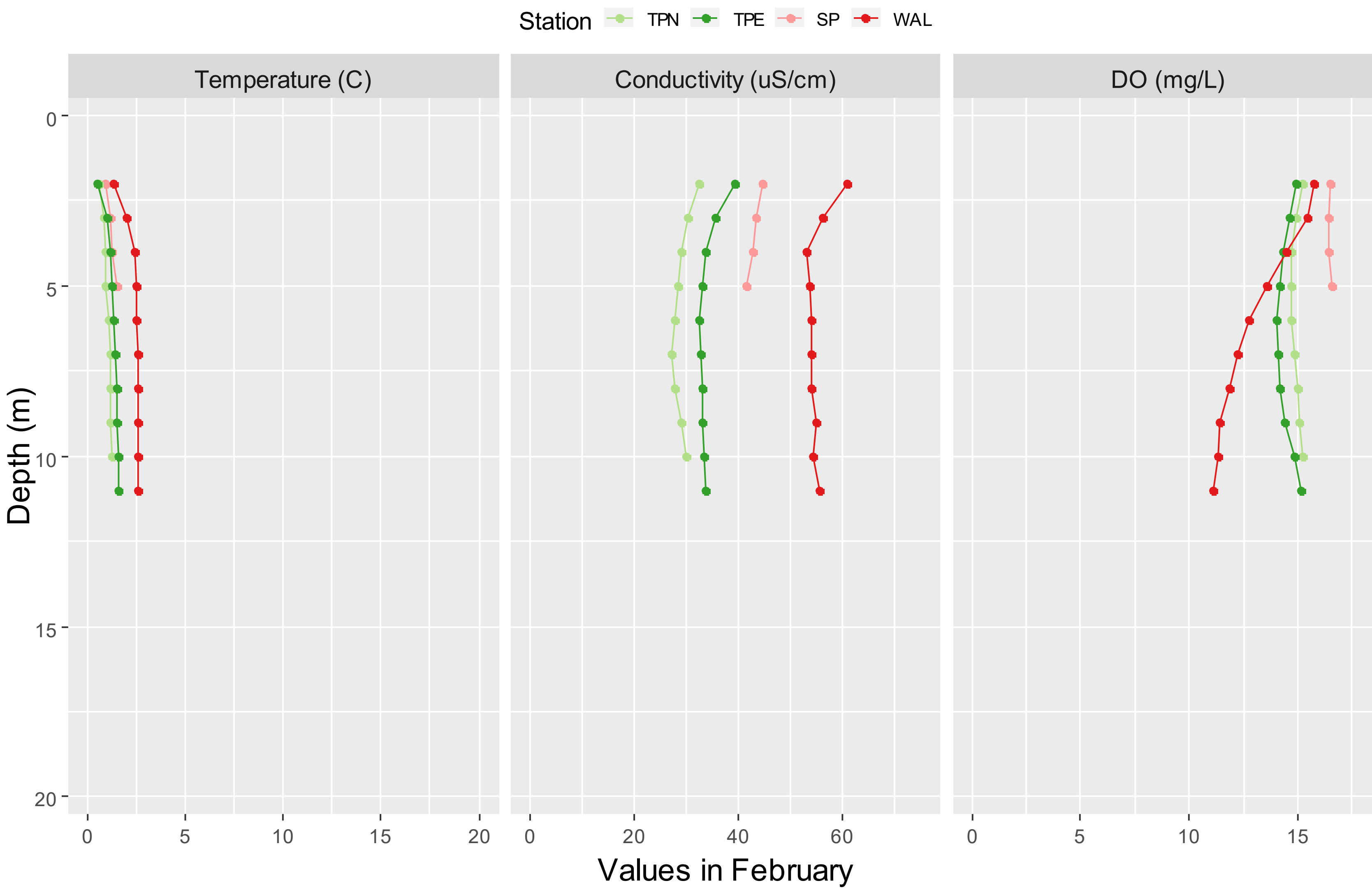


Figure 4-6. Meadowbank – Field-measured temperature, conductivity, and dissolved oxygen profiles, April 2018.

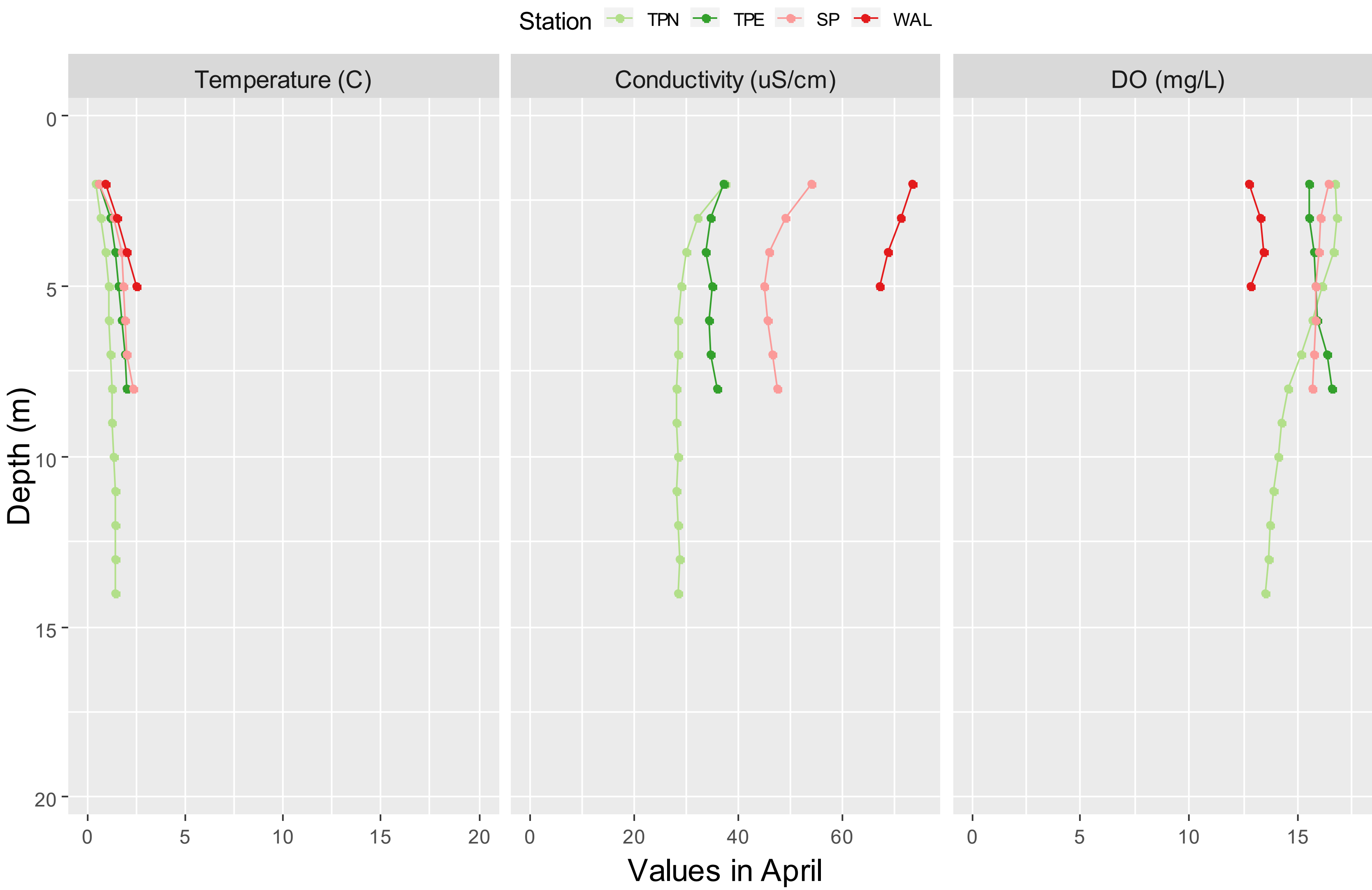


Figure 4-7. Meadowbank – Field-measured temperature, conductivity, and dissolved oxygen profiles, May 2018.

Note: The conductivity readings for WAL at below 4 m were slightly above the upper range of 75 µS/cm. The results are considered reliable.

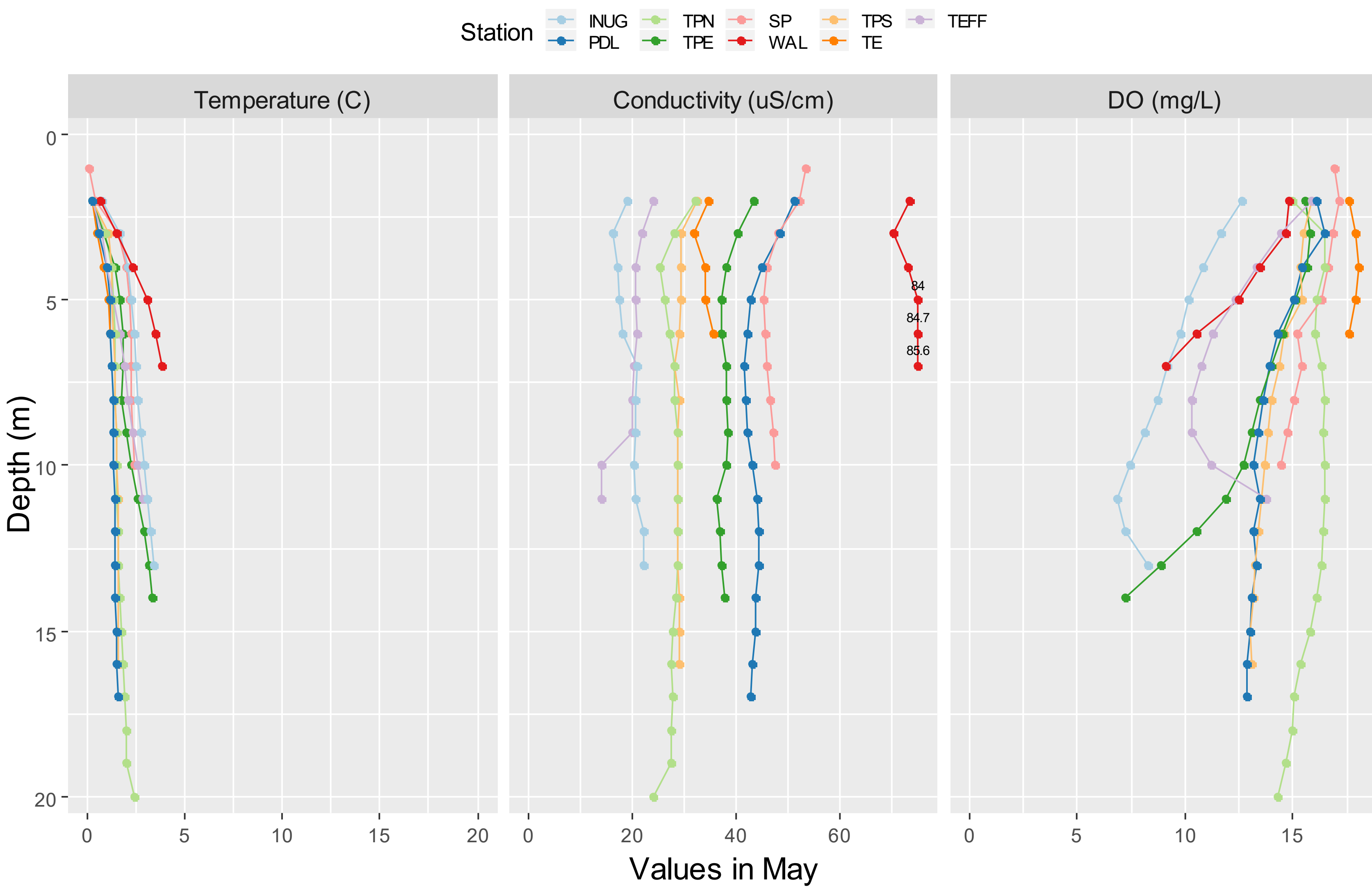


Figure 4-8. Meadowbank – Field-measured temperature, conductivity, and dissolved oxygen profiles, July 2018.

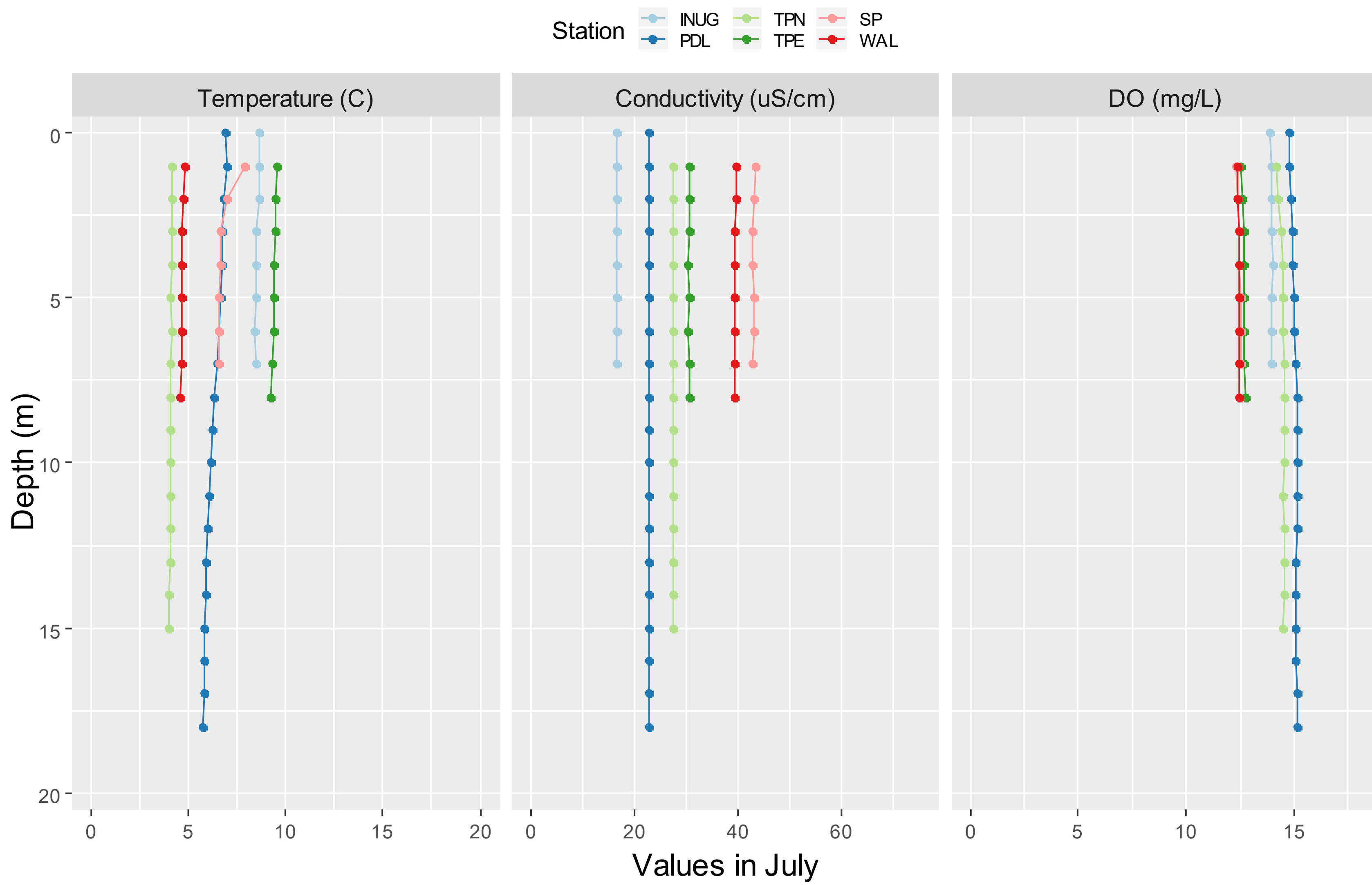


Figure 4-9. Meadowbank – Field-measured temperature, conductivity, and dissolved oxygen profiles, August 2018.

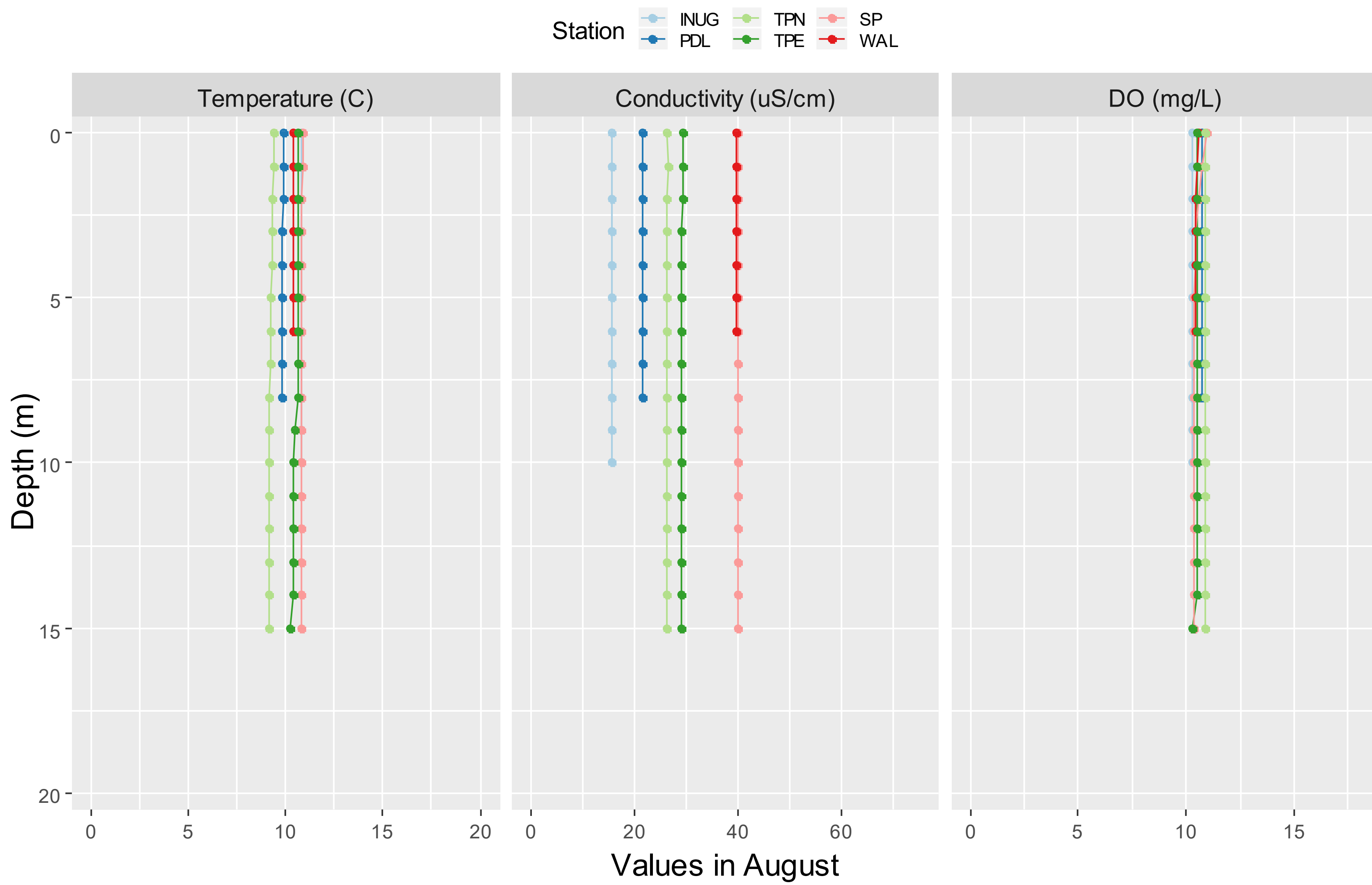


Figure 4-10. Meadowbank – Field-measured temperature, conductivity, and dissolved oxygen profiles, September 2018.

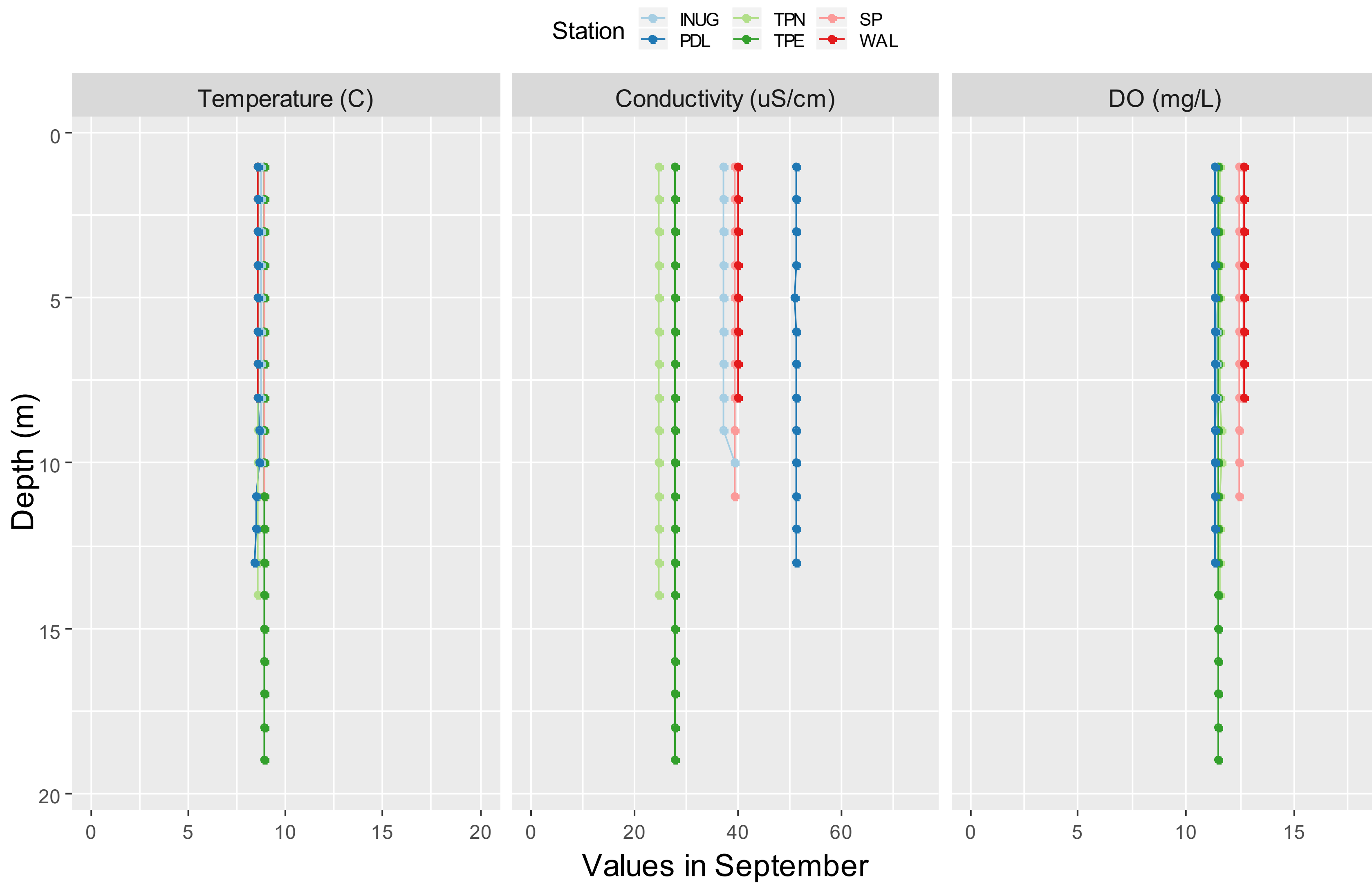


Figure 4-11. Meadowbank – Field-measured temperature, conductivity, and dissolved oxygen profiles, November 2018.

Note: Dissolved oxygen results for PDL are not shown; field readings were record in % rather than mg/L.

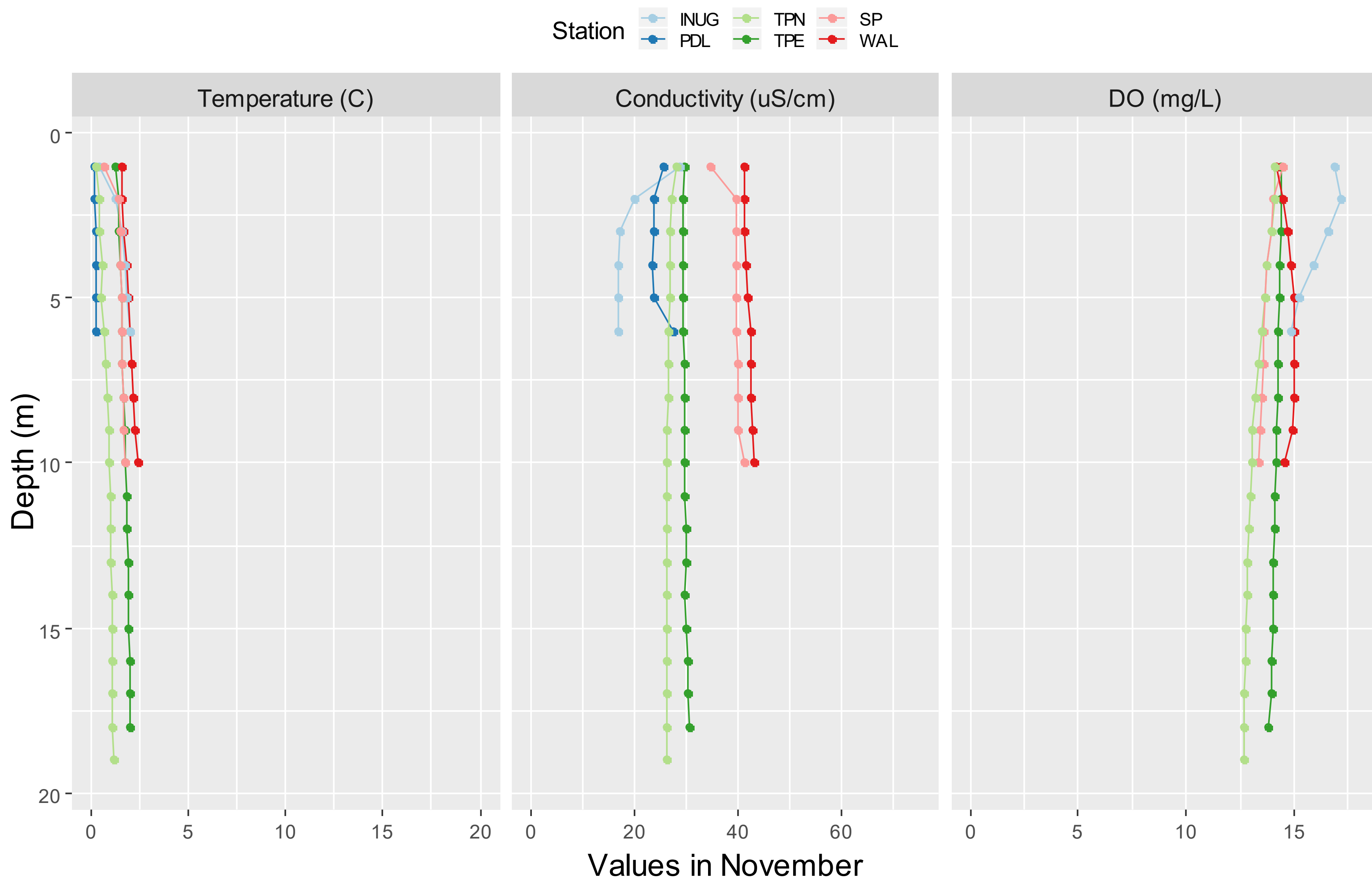
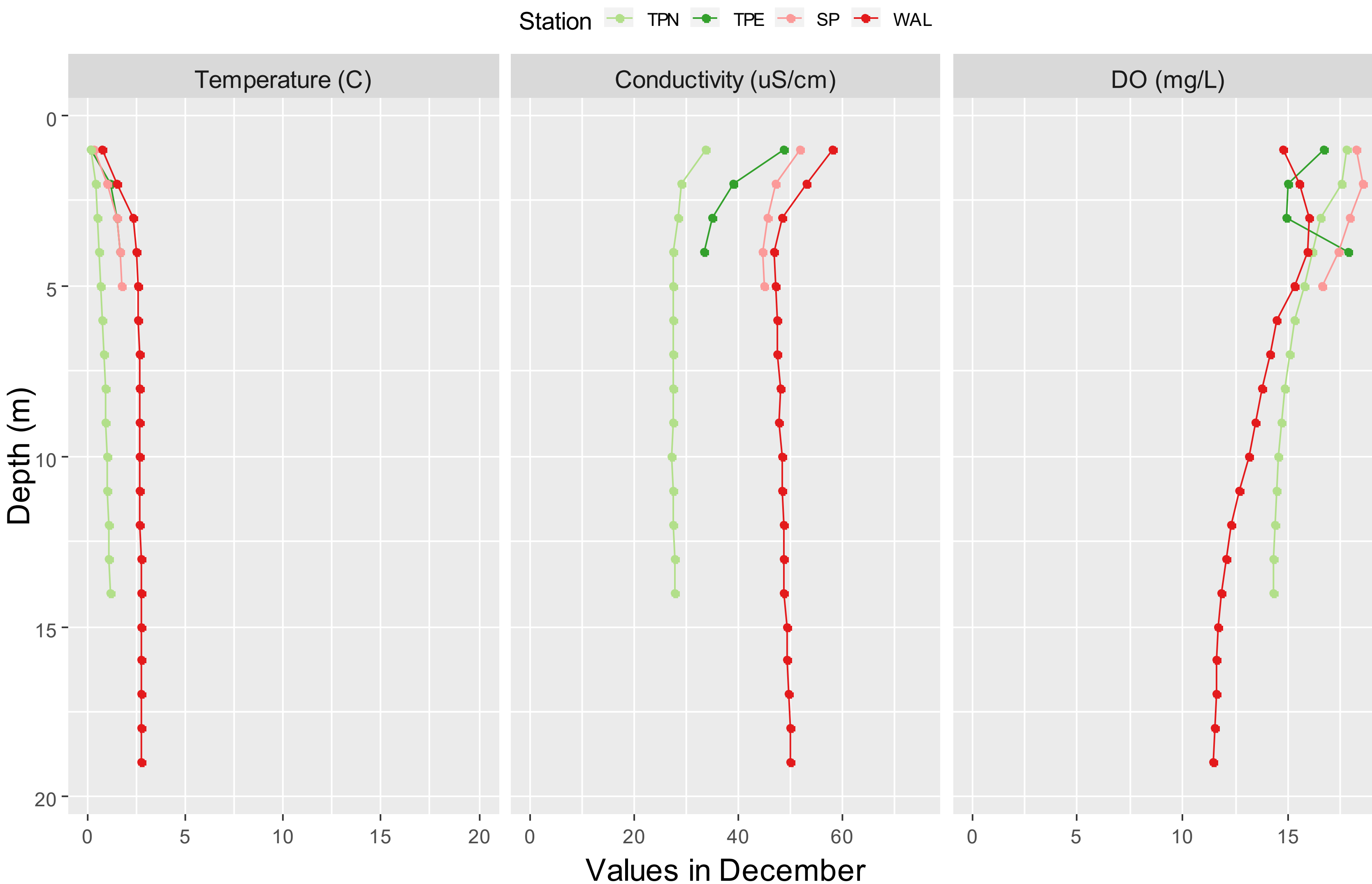


Figure 4-12. Meadowbank – Field-measured temperature, conductivity, and dissolved oxygen profiles, December 2018.



Water Chemistry Tables and Figures

Table 4-2. Screening process for water quality parameters, Meadowbank study lakes, 2018.

CONVENTIONALS

Screening Level	1	2	3
Screening Rule[1]	>DL ≥ 10% frequency	C-I > 0.1 frequency	Pattern = Activity
Conductivity	Figure 4-14		
Hardness	Figure 4-15		
pH -Field	Figure 4-16		
pH -Lab	Figure 4-17		
TSS	Figure 4-18		
TDS	Figure 4-19		
B-Alkalinity	Figure 4-20		
C-Alkalinity*	No	No	No
T-Alkalinity	Figure 4-21		
Ammonia-N	Figure 4-22		
Chloride	Figure 4-23		
Nitrate-N	Figure 4-24		
Nitrite-N*	No	No	No
TKN	Figure 4-25		
T-phosphorous	Figure 4-26		
Ortho-phosphate*	No	No	No
Reactive silica	Figure 4-27		
Sulphate	Figure 4-28		
DOC	Figure 4-29		
TOC	Figure 4-30		
T-Cyanide*	No	No	No
Free Cyanide*	No	No	No

TOTAL METALS

Screening Level	1	2	3
Screening Rule[1]	>DL ≥ 10% frequency	C-I > 0.1 frequency	Pattern = Activity
Aluminum	Figure 4-31		
Antimony*	No	No	No
Arsenic	Figure 4-32		
Barium	Figure 4-33		
Beryllium*	No	No	No
Boron*	No	No	No
Cadmium*	No	No	No
Calcium	Figure 4-34		
Chromium	Figure 4-35		
Copper	Figure 4-36		
Iron	Figure 4-37		
Lead*	No	No	No
Lithium*	No	No	No
Magnesium	Figure 4-38		
Manganese	Figure 4-39		
Mercury*	No	No	No
Molybdenum	Figure 4-40		
Nickel	Figure 4-41		
Potassium	Figure 4-42		
Selenium*	No	No	No
Sodium	Figure 4-43		
Strontium	Figure 4-44		
Thallium*	No	No	No
Tin*	No	No	No
Titanium*	No	No	No
Uranium	Figure 4-45		
Vanadium*	No	No	No
Zinc*	No	No	No

DISSOLVED METALS

Screening Level	1	2	3
Screening Rule[1]	>DL ≥ 10% frequency	C-I > 0.1 frequency	Pattern = Activity
Aluminum	Figure 4-46		
Antimony*	No	No	No
Arsenic	Figure 4-47		
Barium	Figure 4-48		
Beryllium*	No	No	No
Boron*	No	No	No
Cadmium*	No	No	No
Chromium*	No	No	No
Copper	Figure 4-49		
Iron*	No	No	No
Lead*	No	No	No
Lithium*	No	No	No
Manganese	Figure 4-50		
Mercury*	No	No	No
Molybdenum	Figure 4-51		
Nickel*	No	No	No
Selenium*	No	No	No
Strontium	Figure 4-52		
Thallium*	No	No	No
Tin*	No	No	No
Titanium*	No	No	No
Uranium	Figure 4-53		
Vanadium*	No	No	No
Zinc*	No	No	No

Notes:
"*" indicates plots for these parameters are presented in **Appendix B1**.
1. See **Section 3.3** for information on the screening process for deciding which parameters are carried forward in the temporal and spatial trend assessment.

Table 4-3. Water quality variables at the Meadowbank areas for which 2018 mean concentration exceeded the trigger.

Meadowbank Areas

Parameter	Trigger	2018 Mean		
		TPN	TPE	SP
Total alkalinity [1]	8.55	-	8.65	12.5
Conductivity	23.51	28.6	32.0	42.5
Hardness	8.49	9.38	11.2	17.0
Calcium	2.15	2.30	2.77	4.43
Potassium	0.5	-	0.54	0.57
Magnesium	0.83	0.92	1.05	1.39
Sodium	0.98	1.13	1.13	-
TDS	18	18.9	20.6	24.49

Wally Lake

Parameter	Trigger	2018 Mean
Conductivity	36.6	46.75
Hardness	16.7	20.11
Calcium	4.9	5.2
Magnesium	1.36	1.59
Sodium	0.72	0.74
TDS	25.3	29.2

Notes:
No cases of trigger exceedances at INUG in 2018. Exceedance for reference area PDL not shown.
Reported mean values are all in units of mg/L except for conductivity (µS/cm).
1. Total alkalinity is present entirely as bicarbonate (HCO_3-) at the study areas.

Table 4-4. Results of BACI tests for selected water variables at Meadowbank areas in 2018.

Parameter	Test Area	n(B)	n(A)	Estimate	SE	P-value[1]	Proportional change exp(Est)	Proportional change LCI	Proportional change UCI
Bicarb. alkalinity	TPE	7	5	0.49	0.069	**0.000**	1.62	1.39	1.89
	SP	5	5	0.35	0.035	**0.000**	1.42	1.31	1.54
Total alkalinity	TPE	7	5	0.49	0.069	**0.000**	1.62	1.39	1.89
	SP	5	5	0.35	0.035	**0.000**	1.42	1.31	1.54
Conductivity	TPN	6	5	0.56	0.025	**0.000**	1.75	1.65	1.85
	TPE	8	5	0.65	0.045	**0.000**	1.92	1.74	2.12
	SP	5	5	0.44	0.031	**0.000**	1.55	1.44	1.67
	WAL	18	5	0.37	0.077	**0.000**	1.3	1.11	1.52
Hardness	TPN	6	5	0.45	0.023	**0.000**	1.56	1.48	1.65
	TPE	8	5	0.61	0.044	**0.000**	1.84	1.67	2.03
	SP	5	5	0.38	0.02	**0.000**	1.47	1.4	1.54
	WAL	18	5	0.26	0.074	**0.000**	1.4	1.22	1.6
Calcium	TPN	6	5	0.53	0.021	**0.000**	1.69	1.61	1.78
	TPE	8	5	0.69	0.046	**0.000**	1.99	1.79	2.2
	SP	5	5	0.43	0.018	**0.000**	1.54	1.48	1.6
	WAL	18	5	0.28	0.045	**0.000**	1.32	1.2	1.45
Potassium	TPE	8	5	0.34	0.055	**0.000**	1.4	1.24	1.58
	SP	5	5	0.35	0.053	**0.000**	1.42	1.25	1.6
Magnesium	TPN	6	5	0.39	0.024	**0.000**	1.48	1.4	1.56
	TPE	8	5	0.51	0.048	**0.000**	1.66	1.49	1.84
	SP	5	5	0.35	0.025	**0.000**	1.42	1.34	1.51
	WAL	18	5	0.30	0.048	**0.000**	1.35	1.22	1.49
Sodium	TPN	6	5	0.67	0.036	**0.000**	1.95	1.8	2.12
	TPE	8	5	0.68	0.056	**0.000**	1.98	1.75	2.24
	SP	5	5	0.50	0.081	**0.000**	1.65	1.37	1.99
	WAL	18	5	0.18	0.059	**0.003**	1.19	1.06	1.35
TDS	TPN	6	5	0.33	0.075	**0.001**	1.39	1.18	1.65
	TPE	8	5	0.53	0.066	**0.000**	1.7	1.47	1.97
	SP	5	5	0.60	0.09	**0.000**	1.81	1.47	2.23
	WAL	18	5	0.32	0.162	**0.031**	1.38	0.98	1.93

Notes:
1. Bolded values are p-values < 0.05
Test area = area compared to control (INUG)
n(B) = number of paired months in the "before" period
n(A) = number of paired months in the "after" period (i.e., in 2018)
Estimate = BACI model estimate of the 2018 change in mean for log-transformed data
SE = standard error of the estimate
P-value = one-tailed test of the null hypothesis (no change or a decrease in mean [opposite for lower pH trigger])
Exp(Est.) = estimated proportional change
LCI = lower 95% confidence interval; UCI = upper 95% confidence interval

Table 4-5. Sampling effort and frequency assessment results for the 2018 Meadowbank area lakes.

Areas	Area Designation	Triggers Exceeded?	Minor Changes [1]		Moderate Changes [2]		Major Changes [3]		Plan for 2019
		Yes/No	Yes/No	Parameters	Yes/No	Parameters	Yes/No	Parameters	
Sampling Strategy for Reference Areas									
INUG	Ref	No	No	-	No	-	No	-	Full CREMP (reference area)
PDL	Ref	Yes	Yes	Alkalinity (HCO_3 & Total), Cond., Hard., Ca, Mg	No	-	No	-	Full CREMP (reference area)
Sampling Strategy for TE and TEFF									
TPE	NF	Yes	Yes	Alkalinity (HCO_3 & Total), Cond., Hard., Ca, K, Mg, Na, TDS	No	-	No	-	Full CREMP (near-field area)
SP	NF	Yes	Yes	Alkalinity (HCO_3 & Total), Cond., Hard., Ca, K, Mg, TDS	No	-	No	-	Full CREMP (near-field area)
WAL	NF	Yes	Yes	Cond., Hard., Ca, Mg, Na, TDS	No	-	No	-	Full CREMP (near-field area)
TE	MF	NA	NA	-	No	-	No	-	Winter through-ice sampling
TEFF	FF	NA	NA	-	No	-	No	-	Winter through-ice sampling
Sampling Strategy for TPS									
TPN	NF	Yes	Yes	Cond., Hard., Ca, Mg, Na, TDS	No	-	No	-	Full CREMP (near-field area)
TPS	MF	NA	NA	-	No	-	No	-	Winter through-ice sampling

Notes:

1. Minor = exceedance of the early warning trigger values for parameters without effects-based threshold values
2. Moderate = exceedance of the early warning trigger values for parameters with effects-based thresholds
3. Major = exceedance of the effects-based threshold values

NA = MF and/or FF stations were not assessed using the formal BACI analysis in the current CREMP year

Figure 4-13. Flow chart showing sampling effort and frequency assessment results for mid-field and far-field sampling in 2018.

Note: Blue-shaded cells show the linkage between 2017 CREMP results and the sampling effort and frequency for mid-field and far-field sampling in 2018. "Minor changes" refer to statistically significant increased concentrations for parameters without effects-based threshold values that exceed the early warning trigger values. Refer to **Section 2.2.3** for more information.

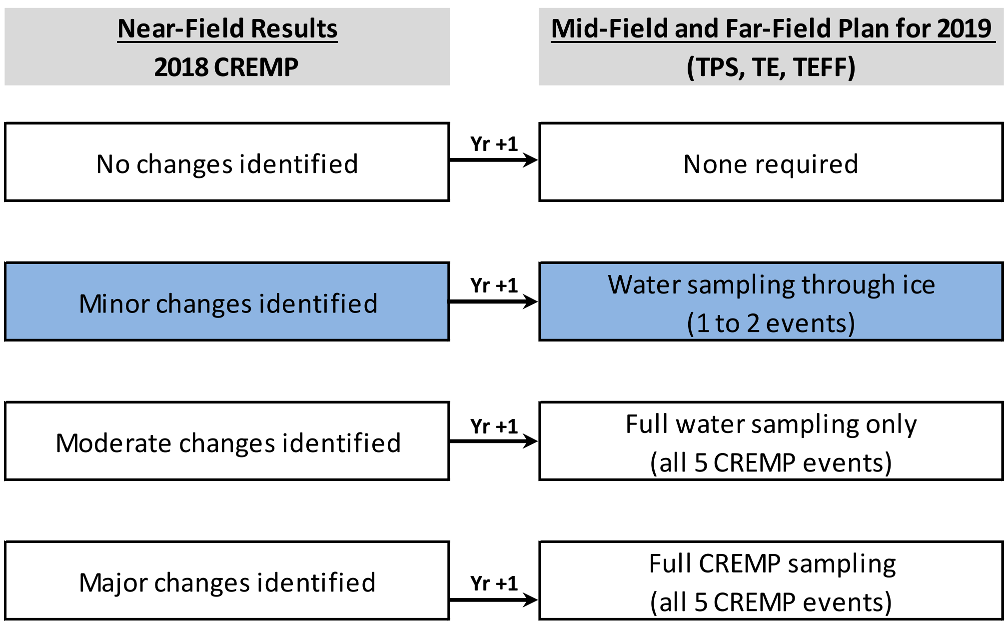


Figure 4-14. Laboratory-measured conductivity (µS/cm) in water samples from Meadowbank Study lakes since 2006.

Note: The red dashed line = trigger value. Conductivity data from 2014 should be interpreted with caution (See Azimuth [2015c] for more details).

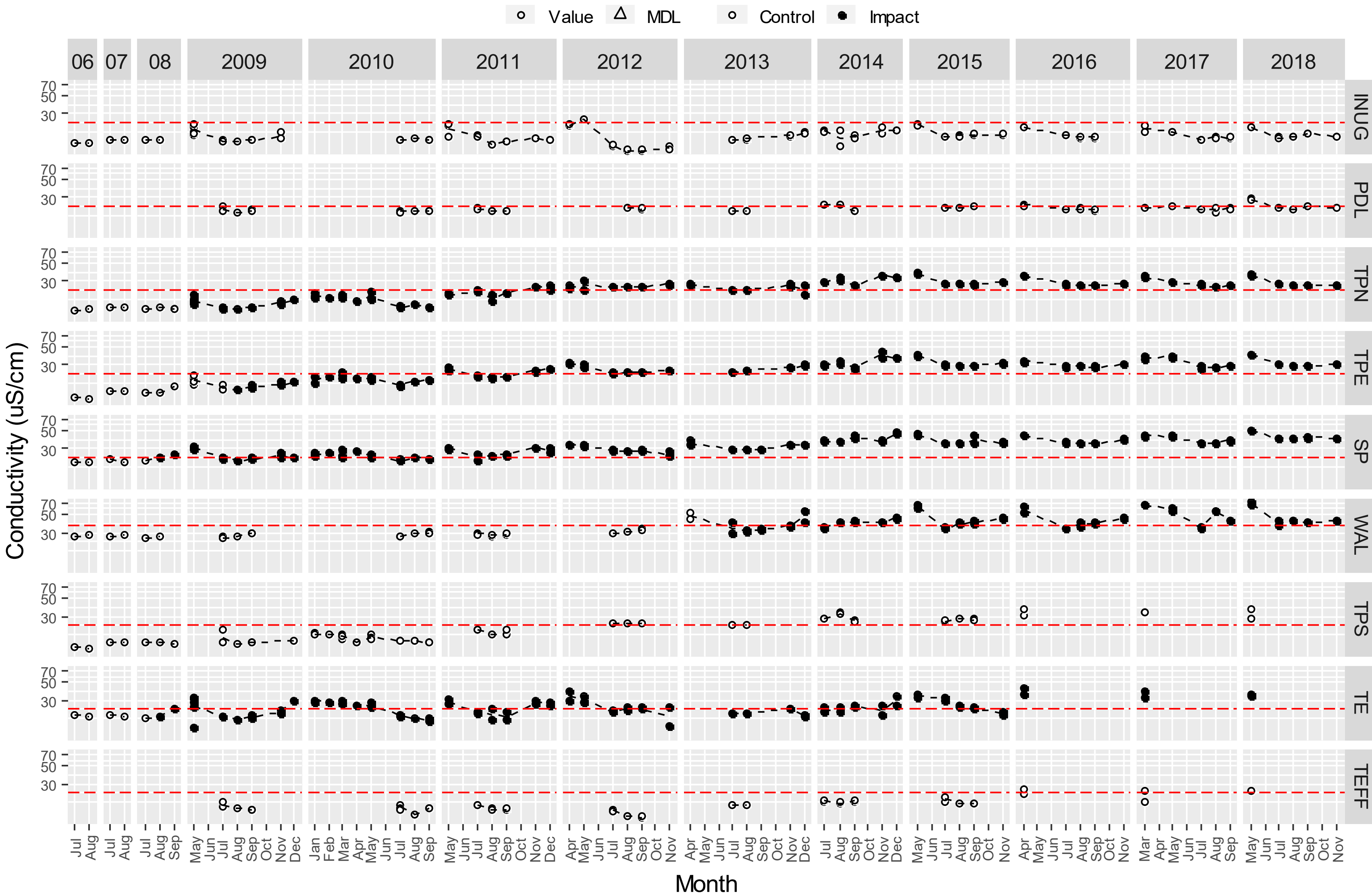


Figure 4-15. Laboratory-measured hardness (mg/L) in water samples from Meadowbank Study lakes since 2006.

Note: The red dashed line = trigger value.

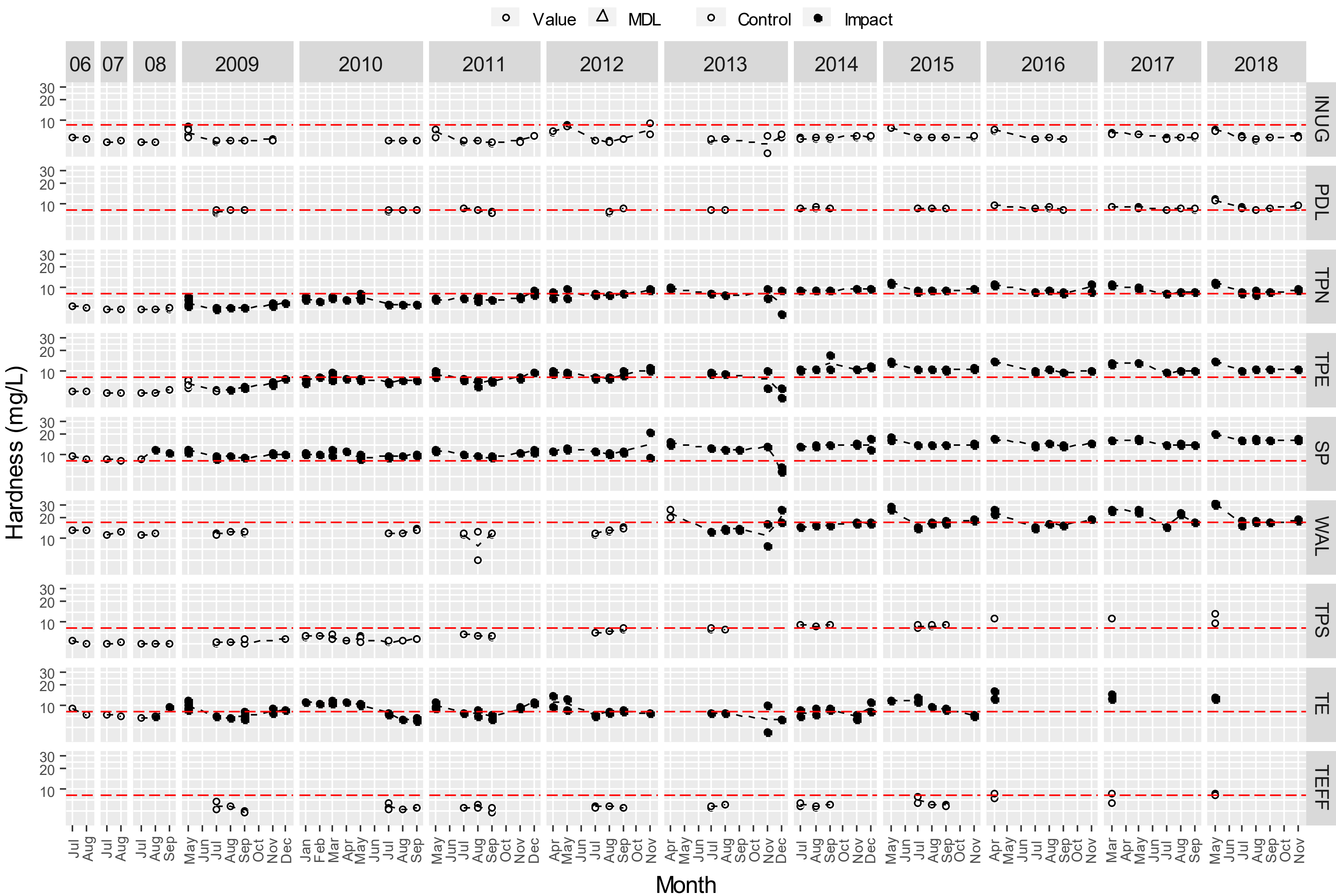


Figure 4-16. Field-measured pH in water samples from Meadowbank Study lakes since 2006.

Note: The red dashed line = trigger value.

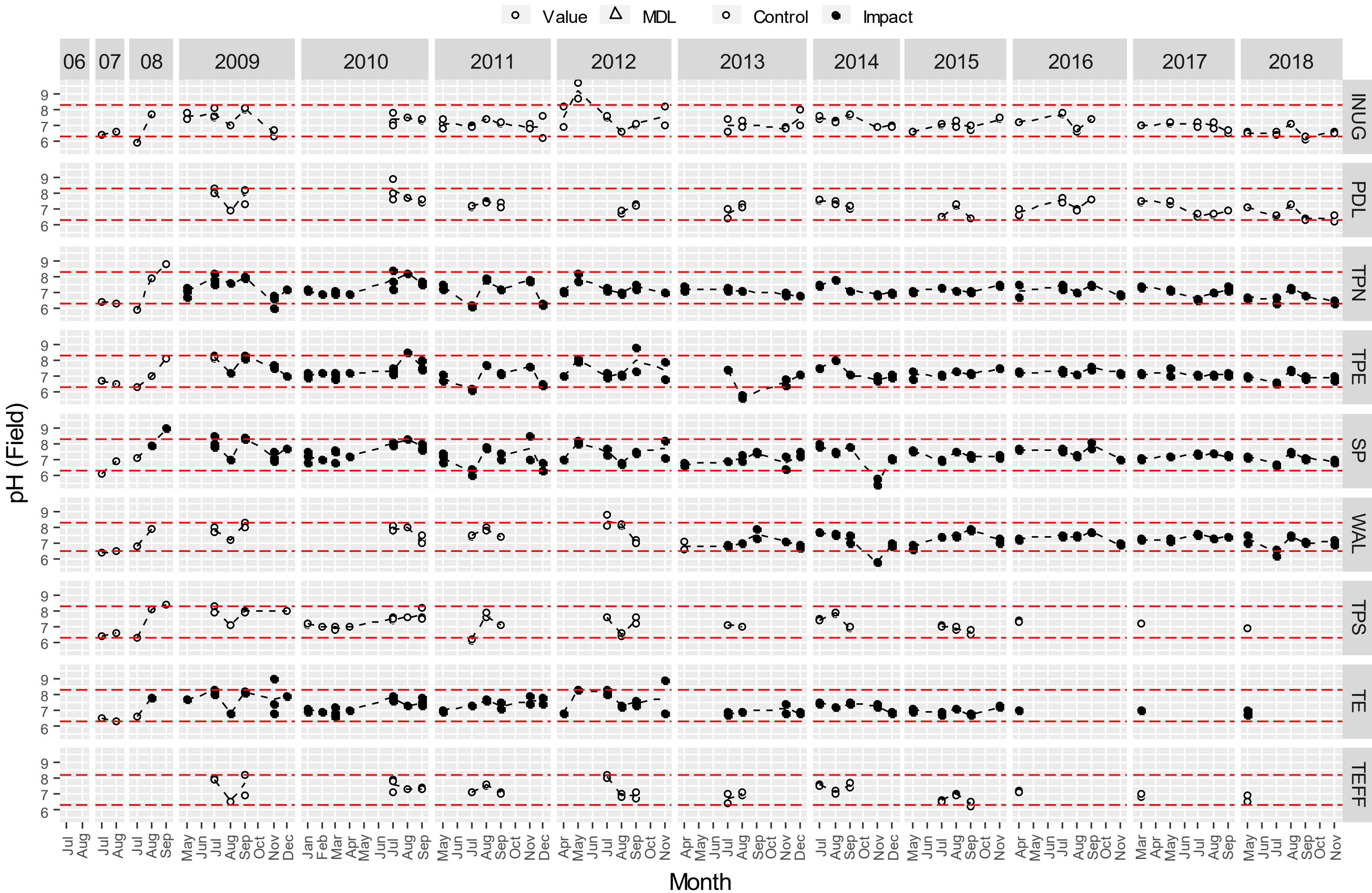


Figure 4-17. Laboratory-measured pH Lab in water samples from Meadowbank Study lakes since 2006.

Note: The red dashed line = trigger value.

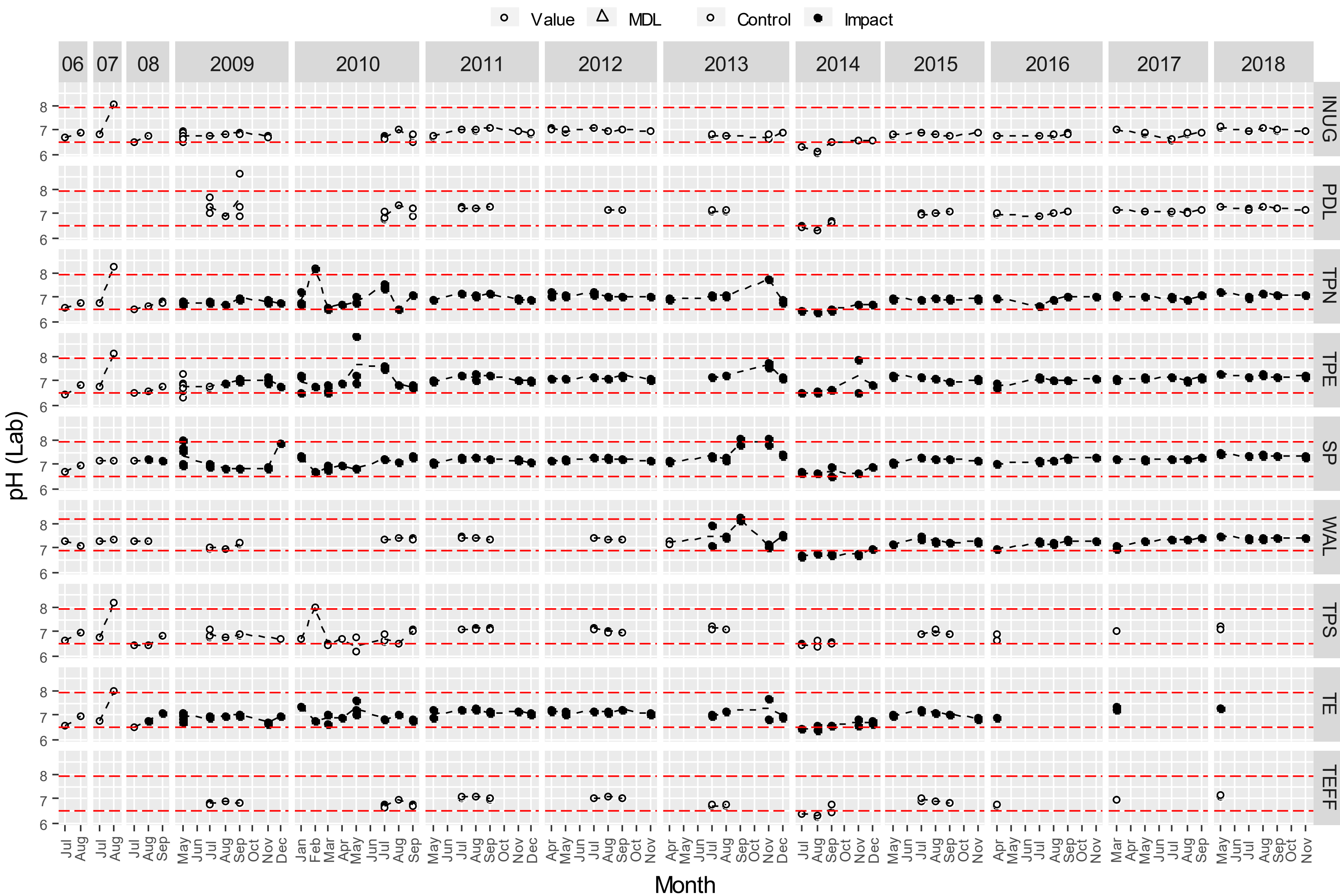


Figure 4-18. Total Suspended Solids (TSS; mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

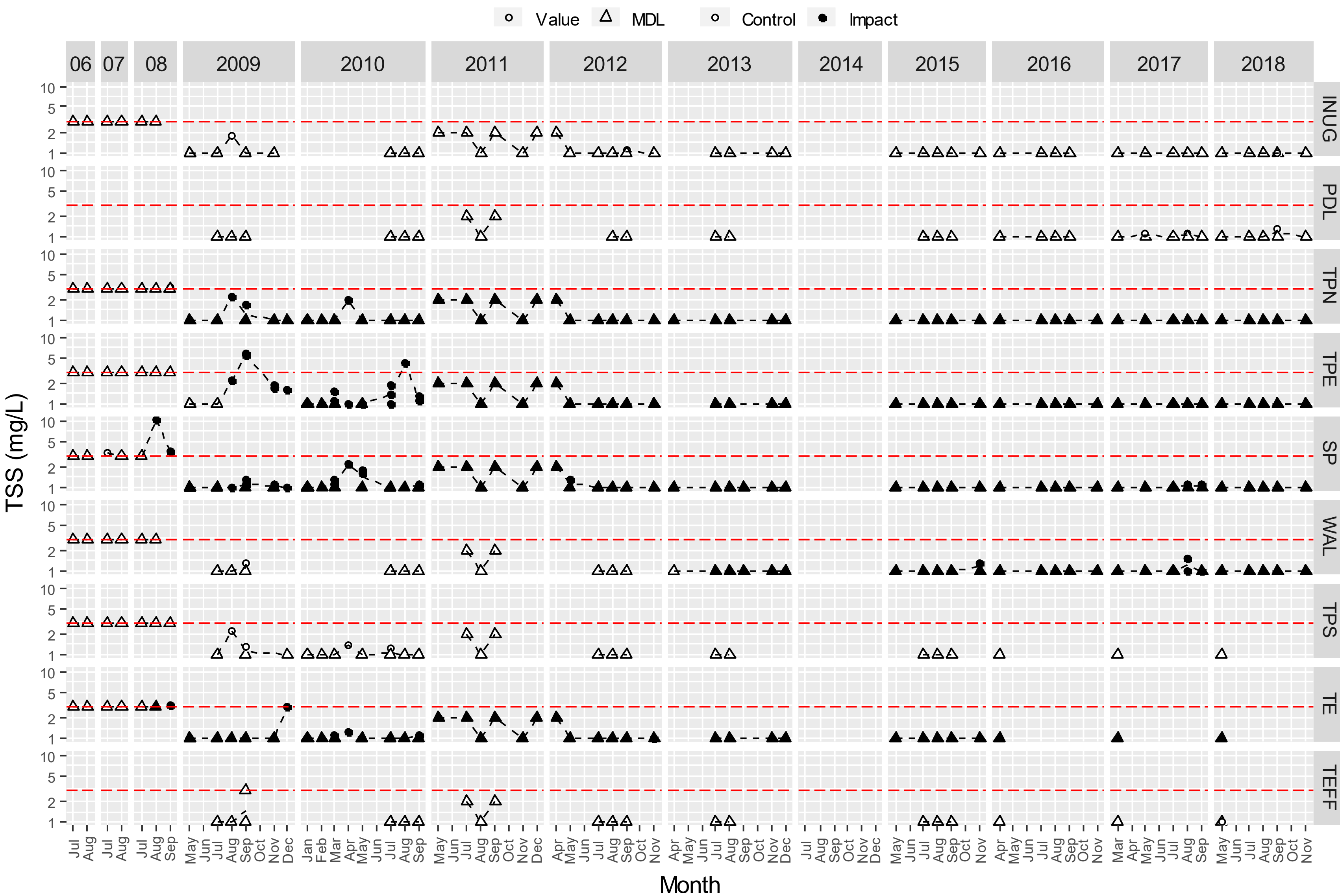


Figure 4-19. Total Dissolved Solids (TDS; mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

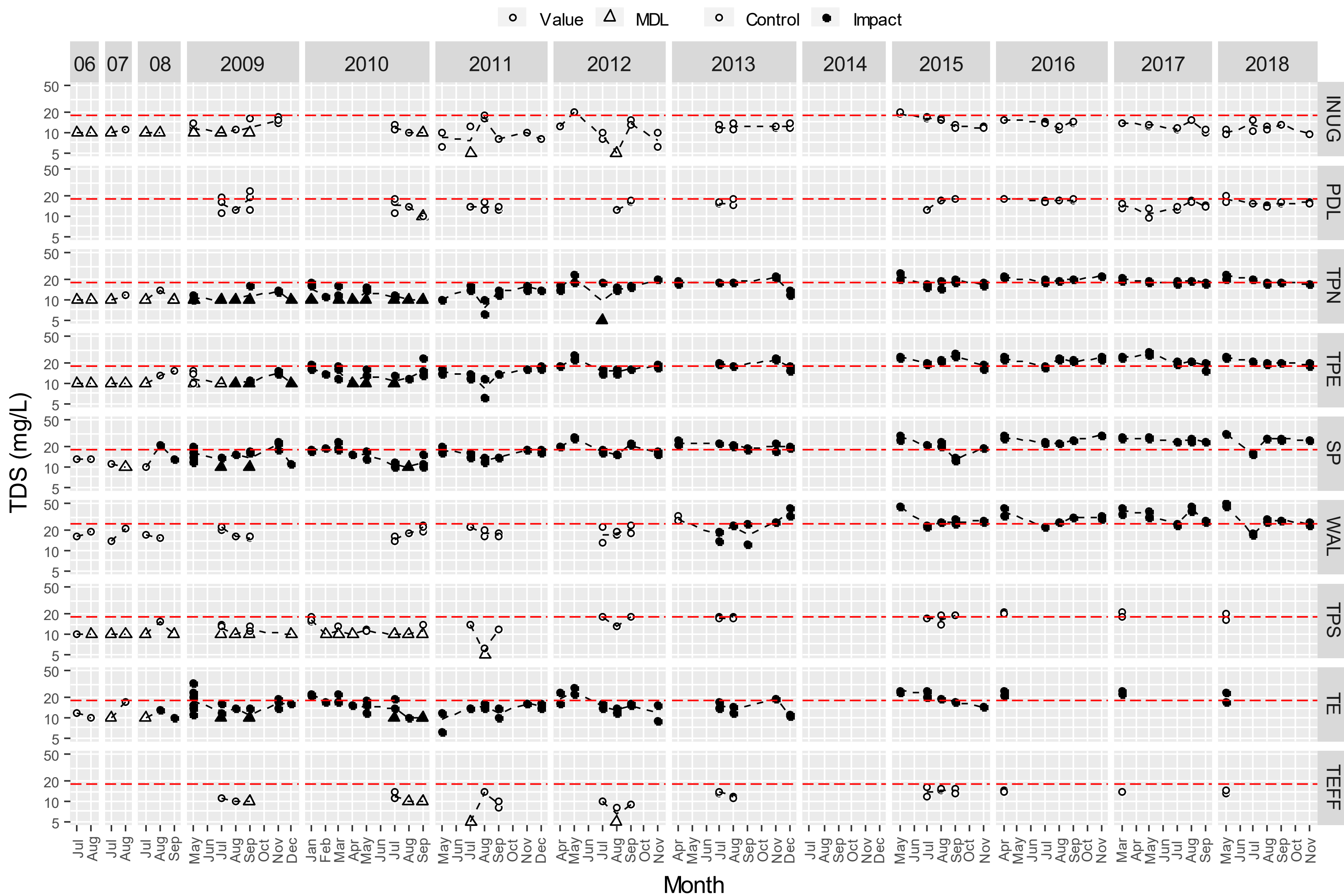


Figure 4-20. Bicarbonate alkalinity (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

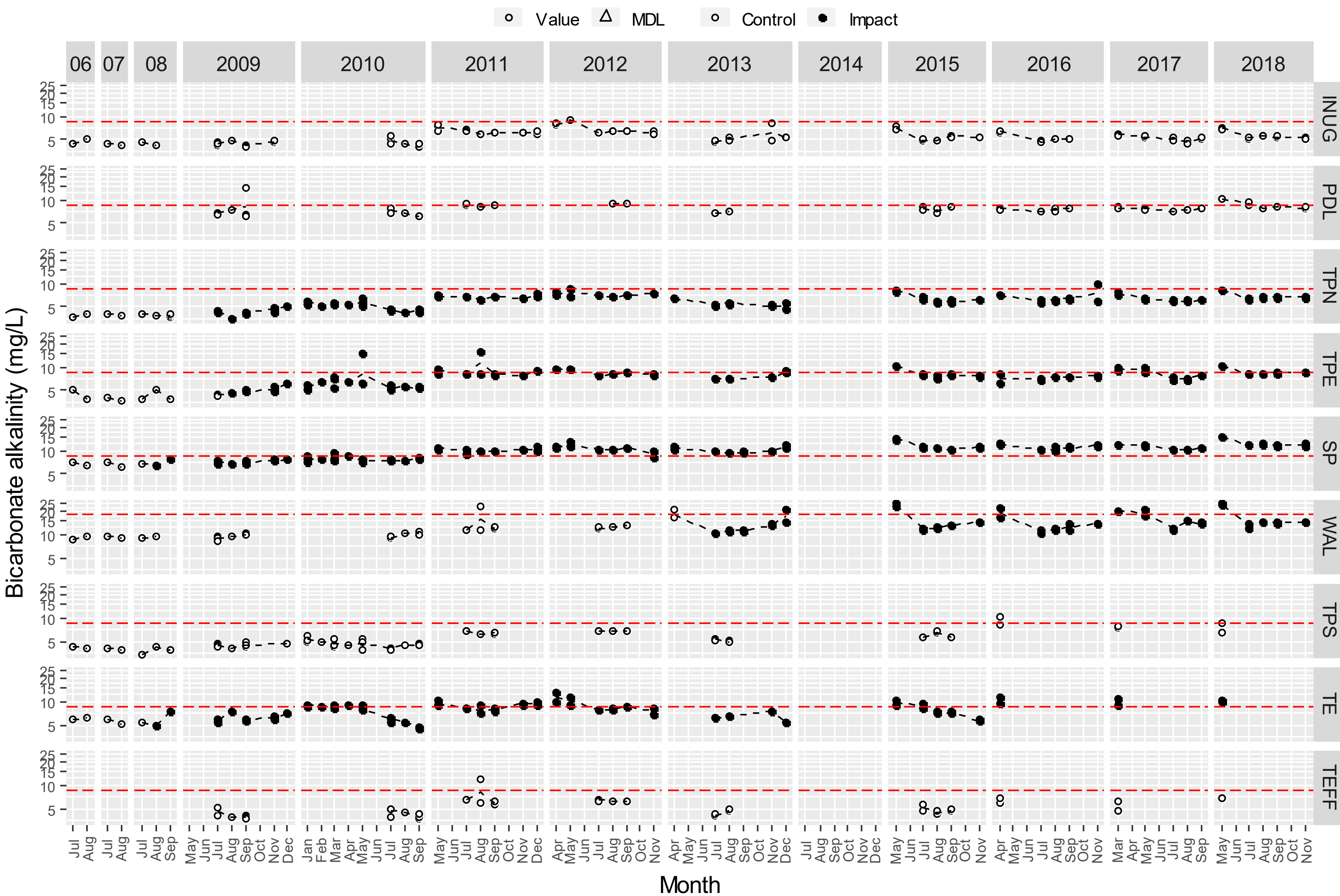


Figure 4-21. Total alkalinity (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

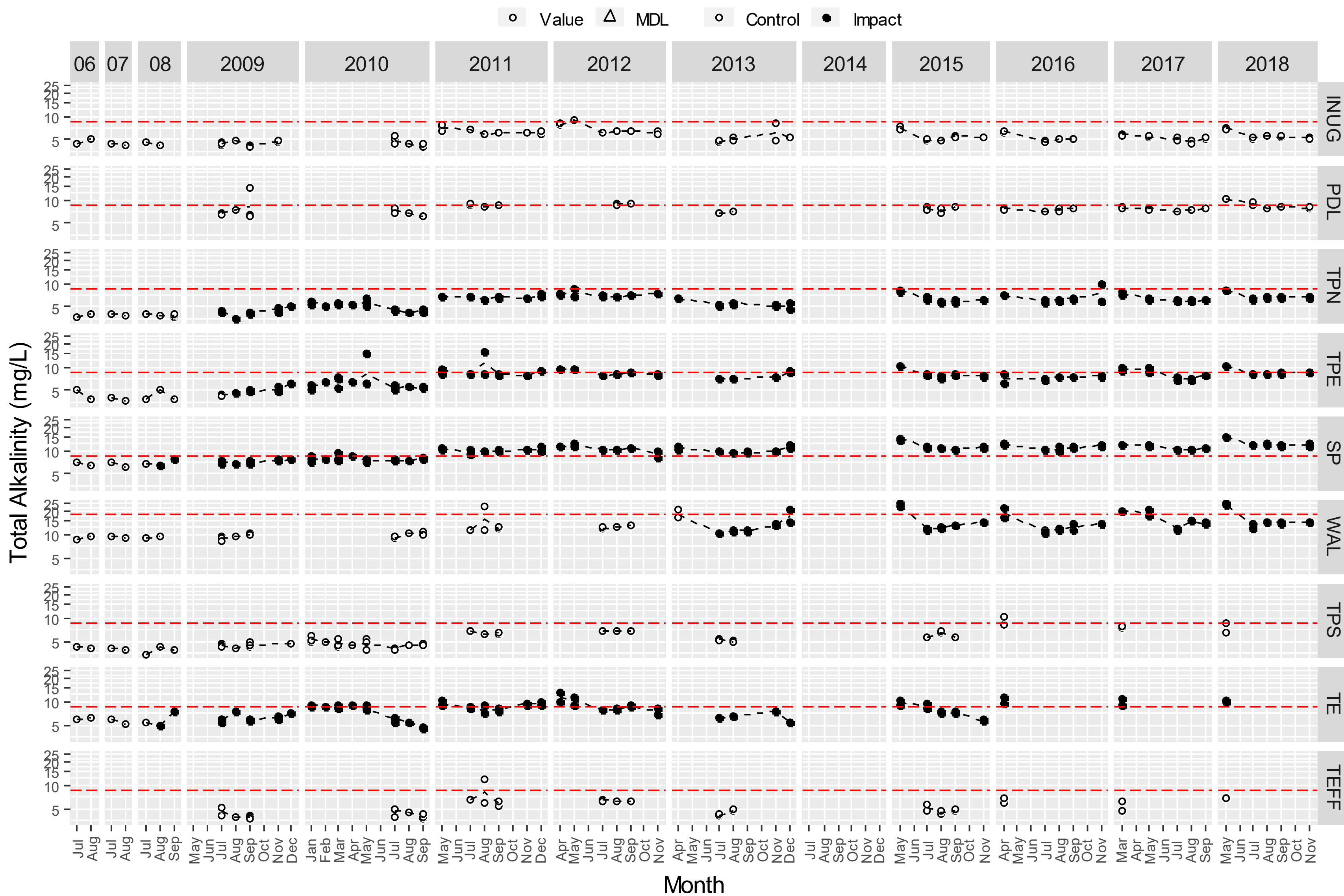


Figure 4-22. Ammonia-N (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

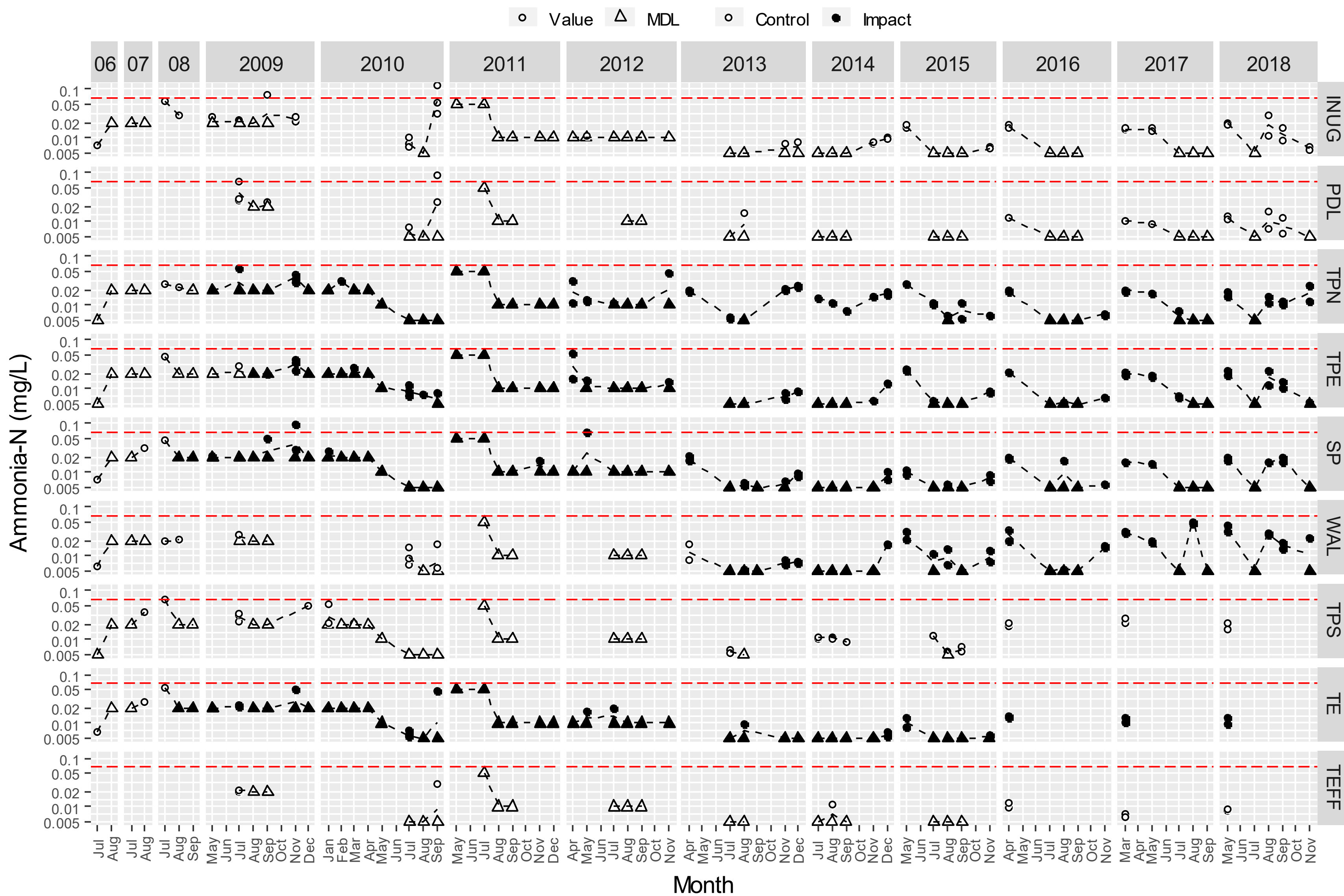


Figure 4-23. Chloride (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

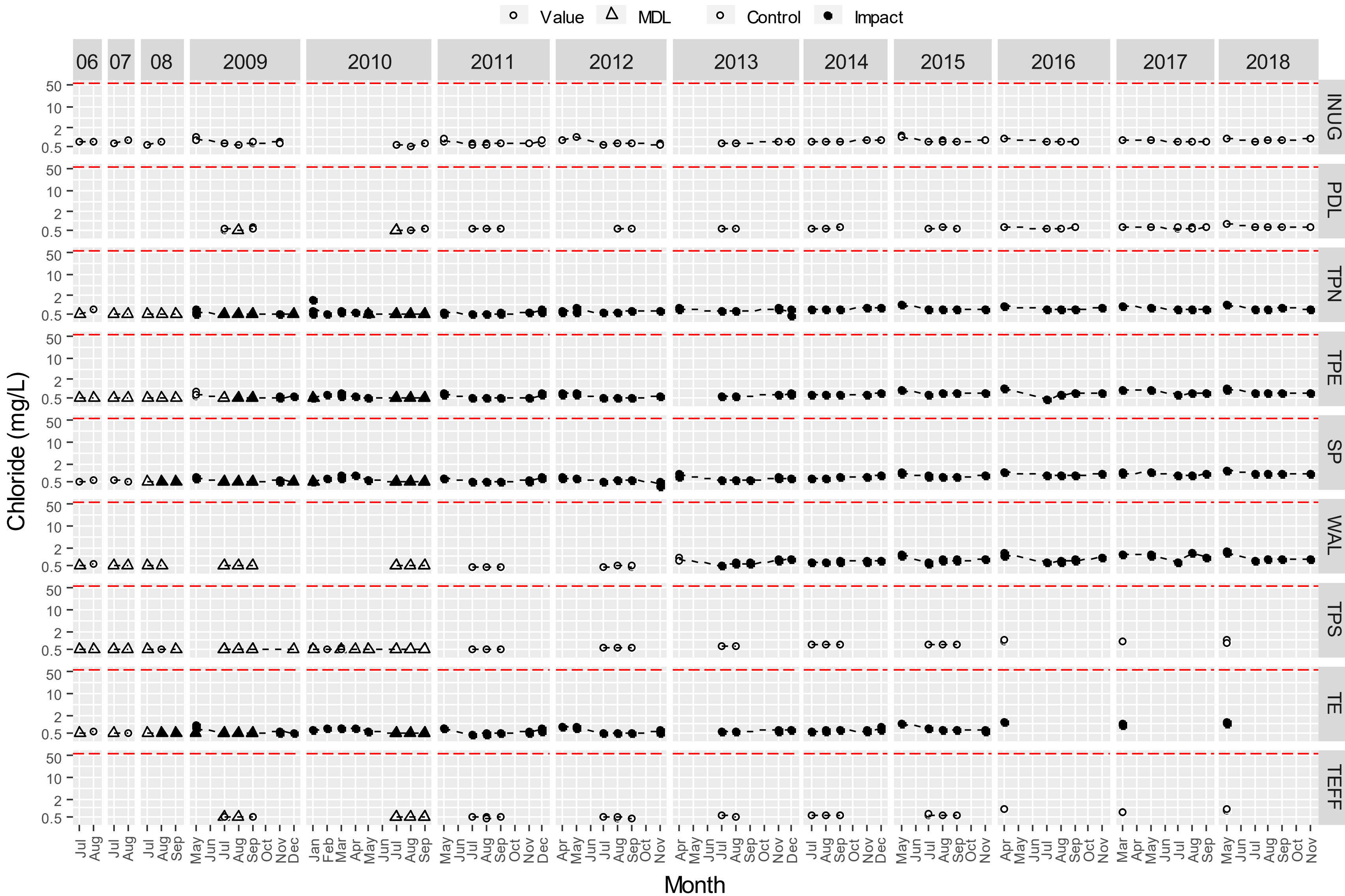


Figure 4-24. Nitrate-N (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

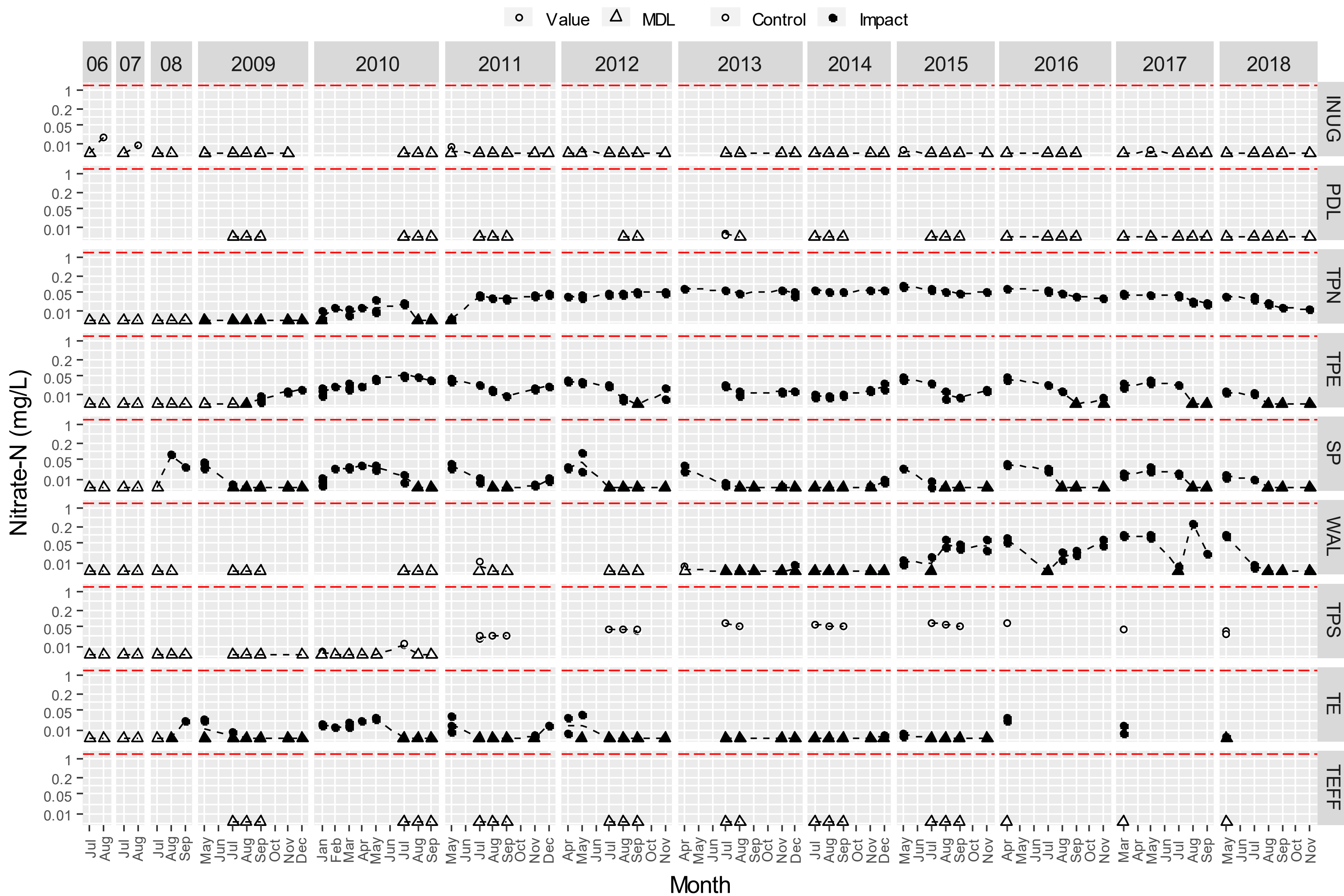


Figure 4-25. Total Kjeldahl Nitrogen (TKN; mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

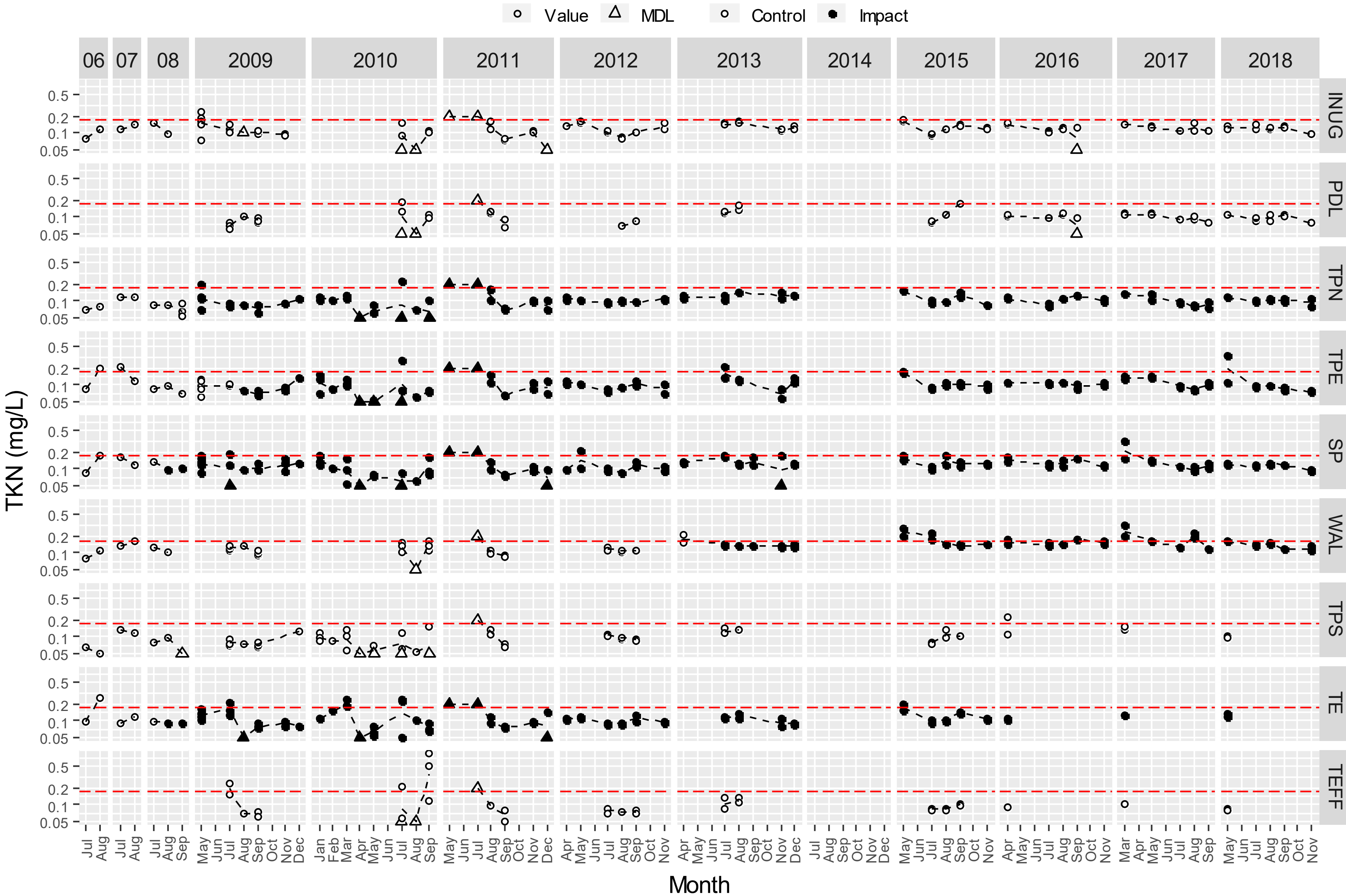


Figure 4-26. Total phosphorus (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

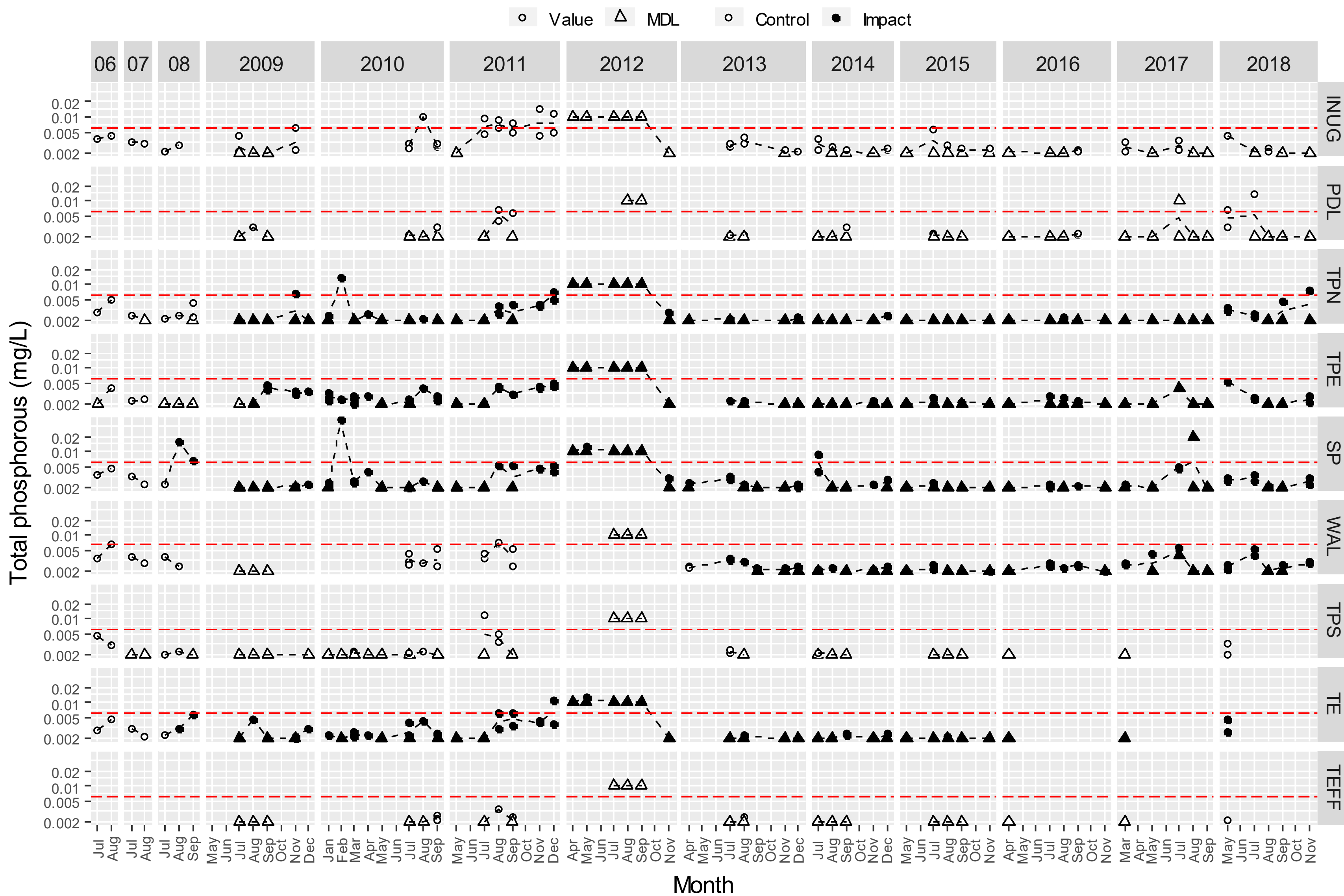


Figure 4-27. Reactive silica (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

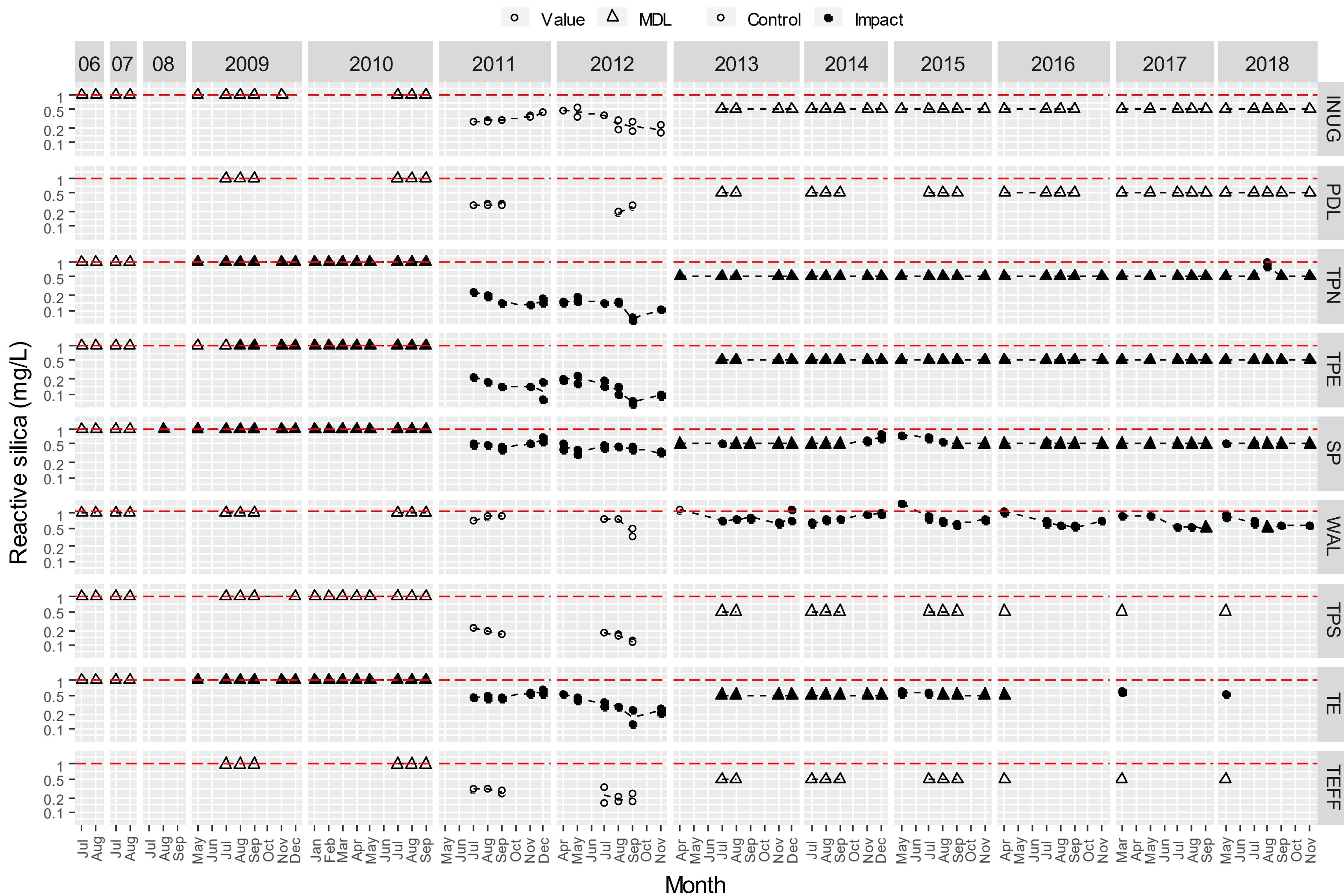


Figure 4-28. Sulphate (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

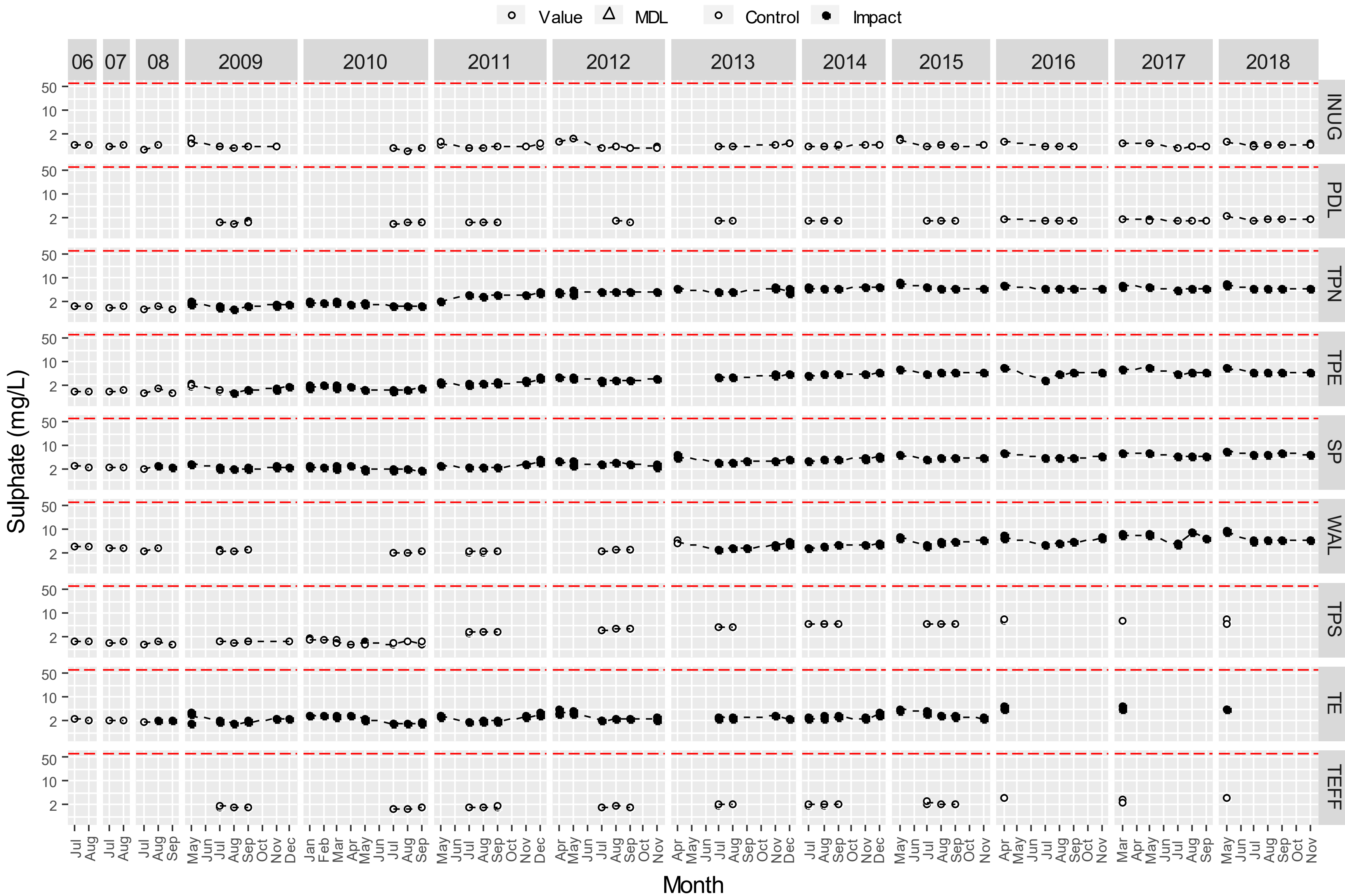


Figure 4-29. Dissolved Organic Carbon (DOC; mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

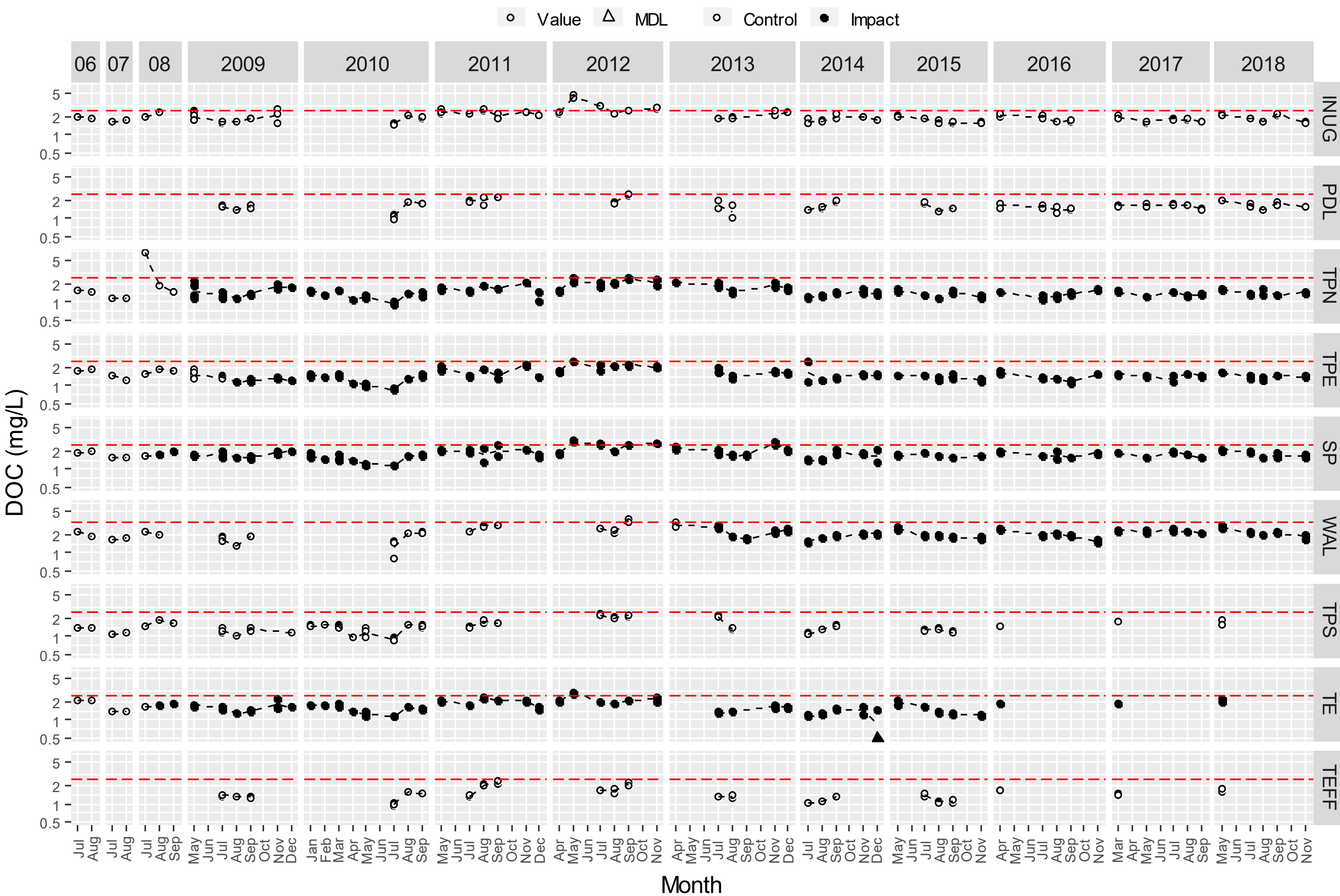


Figure 4-30. Total Organic Carbon (TOC; mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

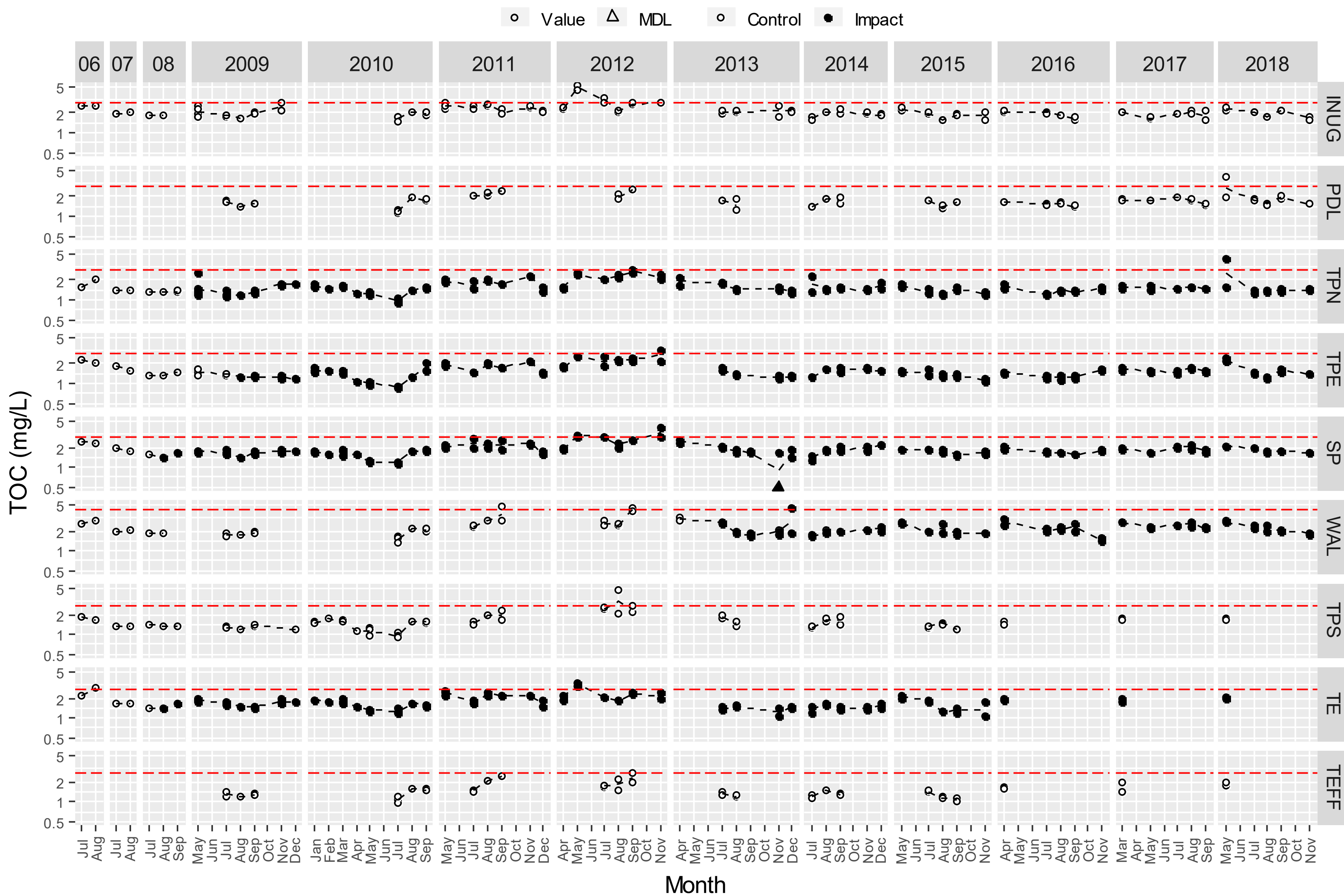


Figure 4-31. Total aluminum (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

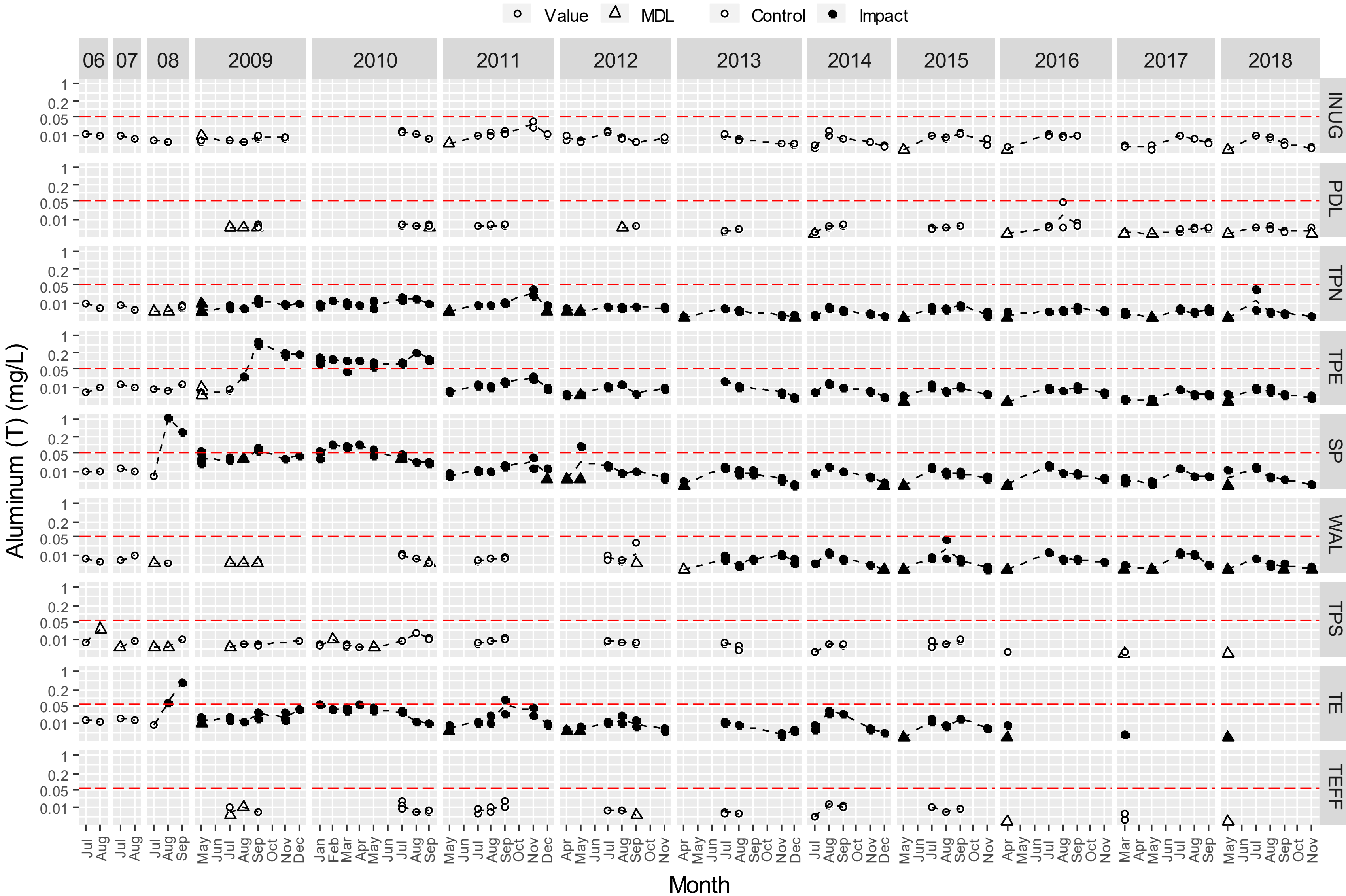


Figure 4-32. Total arsenic (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

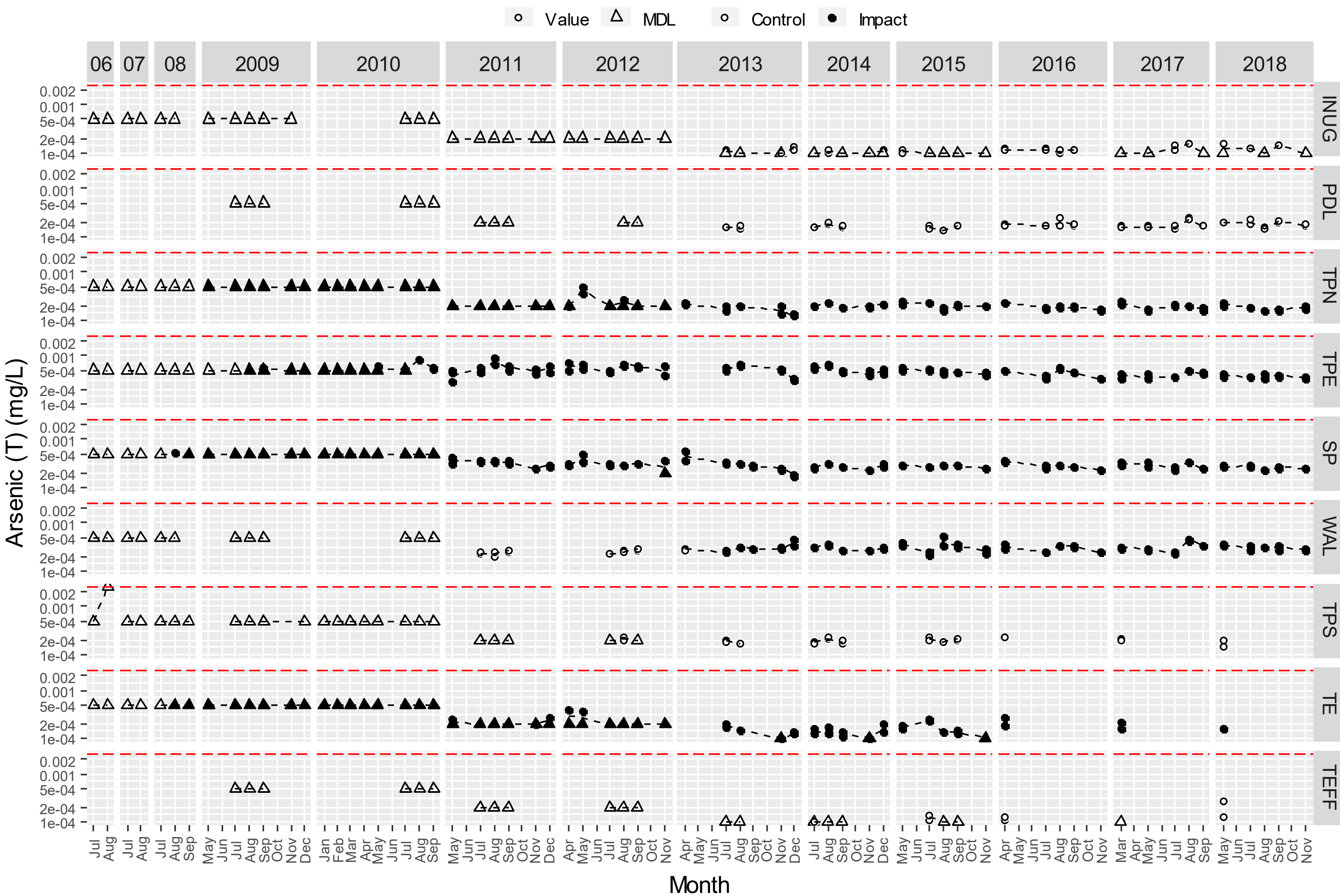


Figure 4-33. Total barium (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

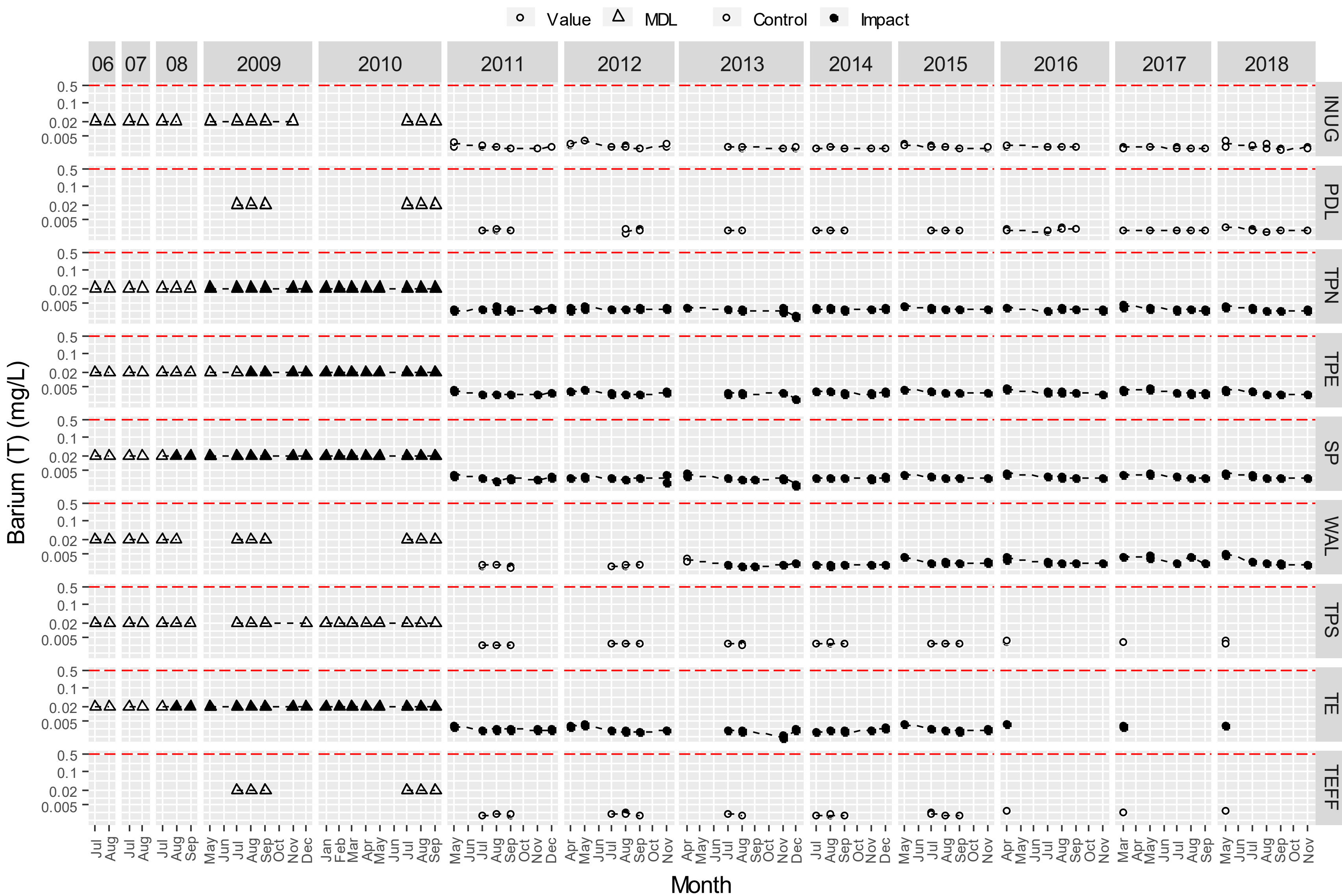


Figure 4-34. Total calcium (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

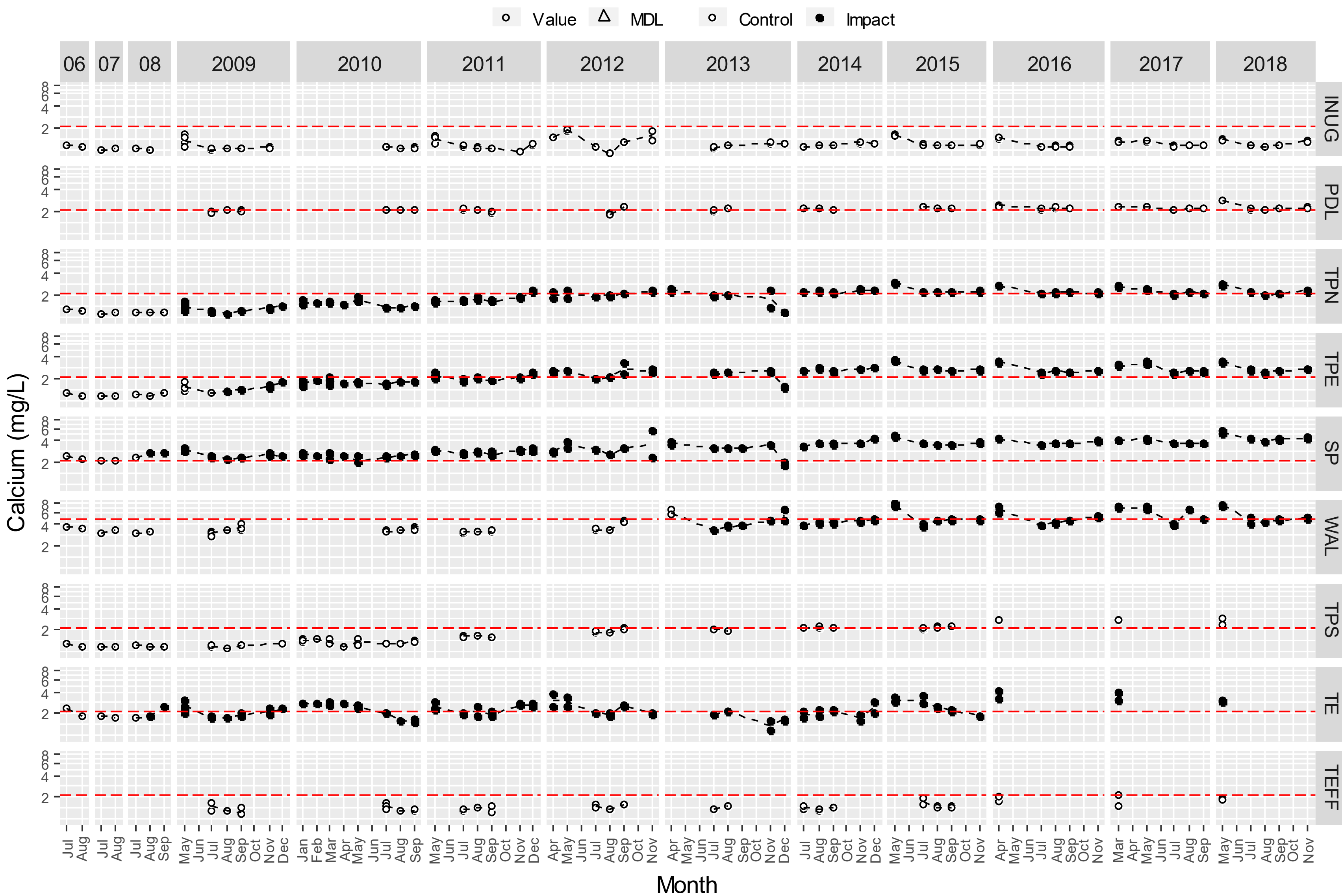


Figure 4-35. Total chromium (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

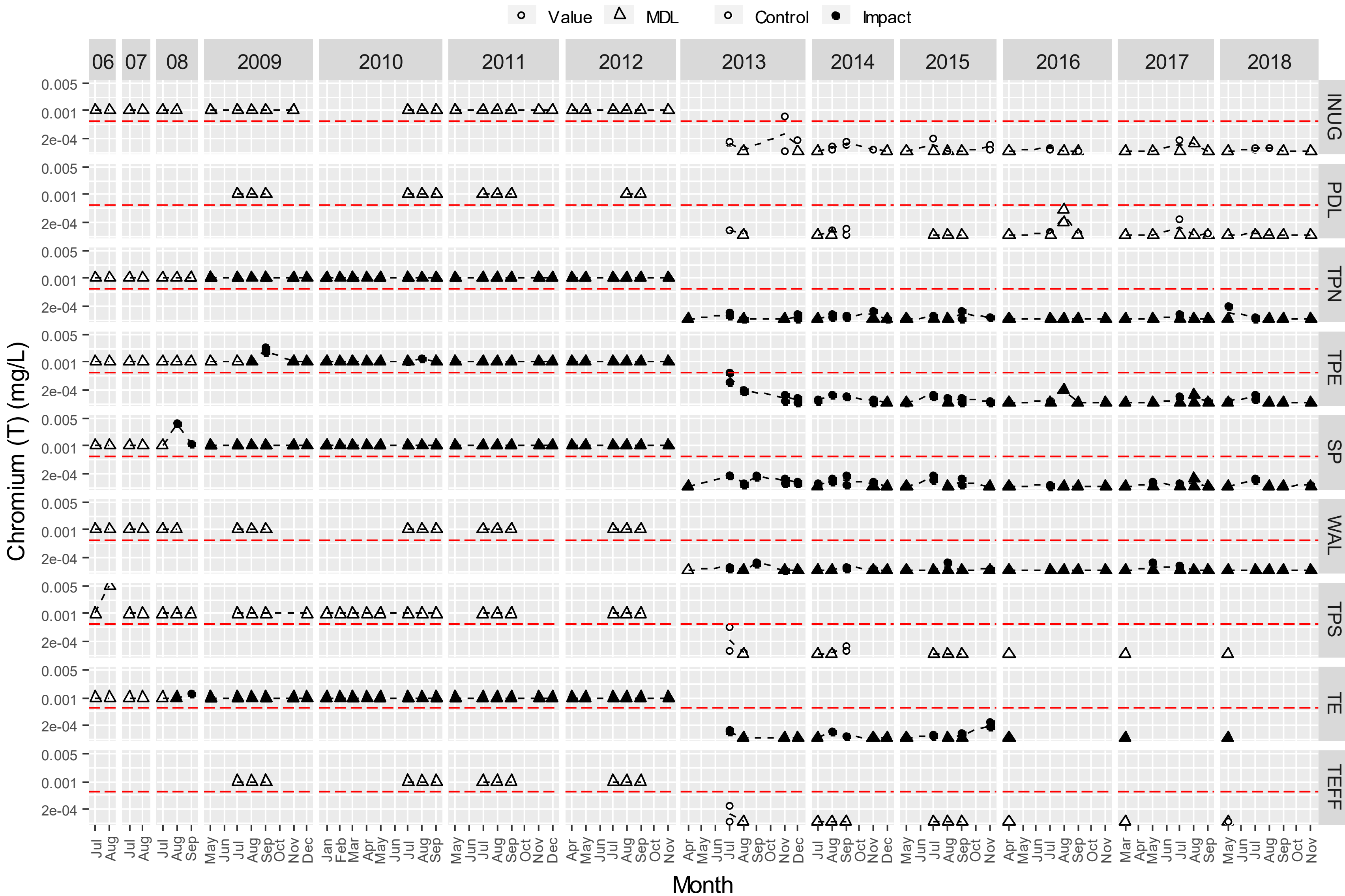


Figure 4-36. Total copper (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

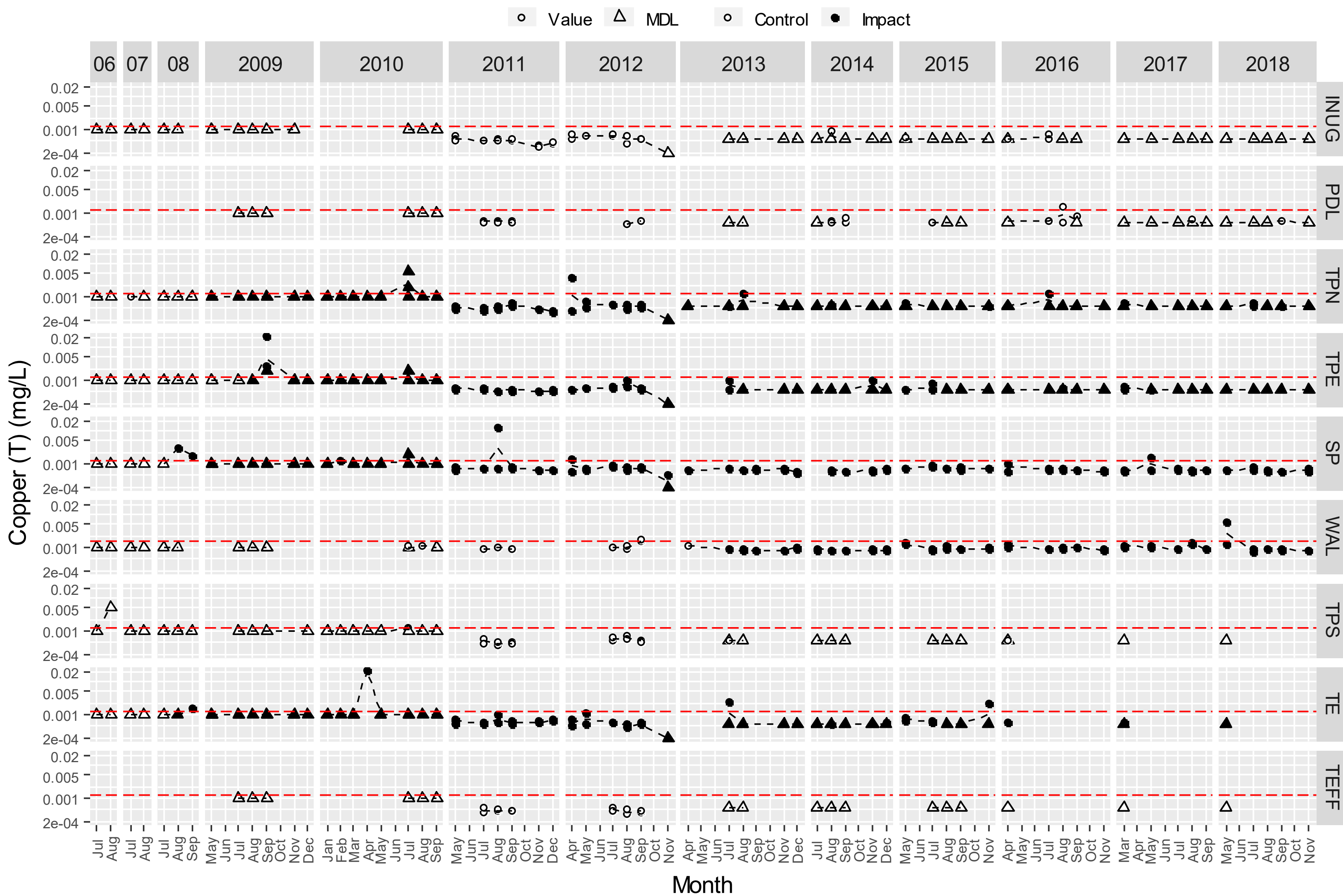


Figure 4-37. Total iron (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

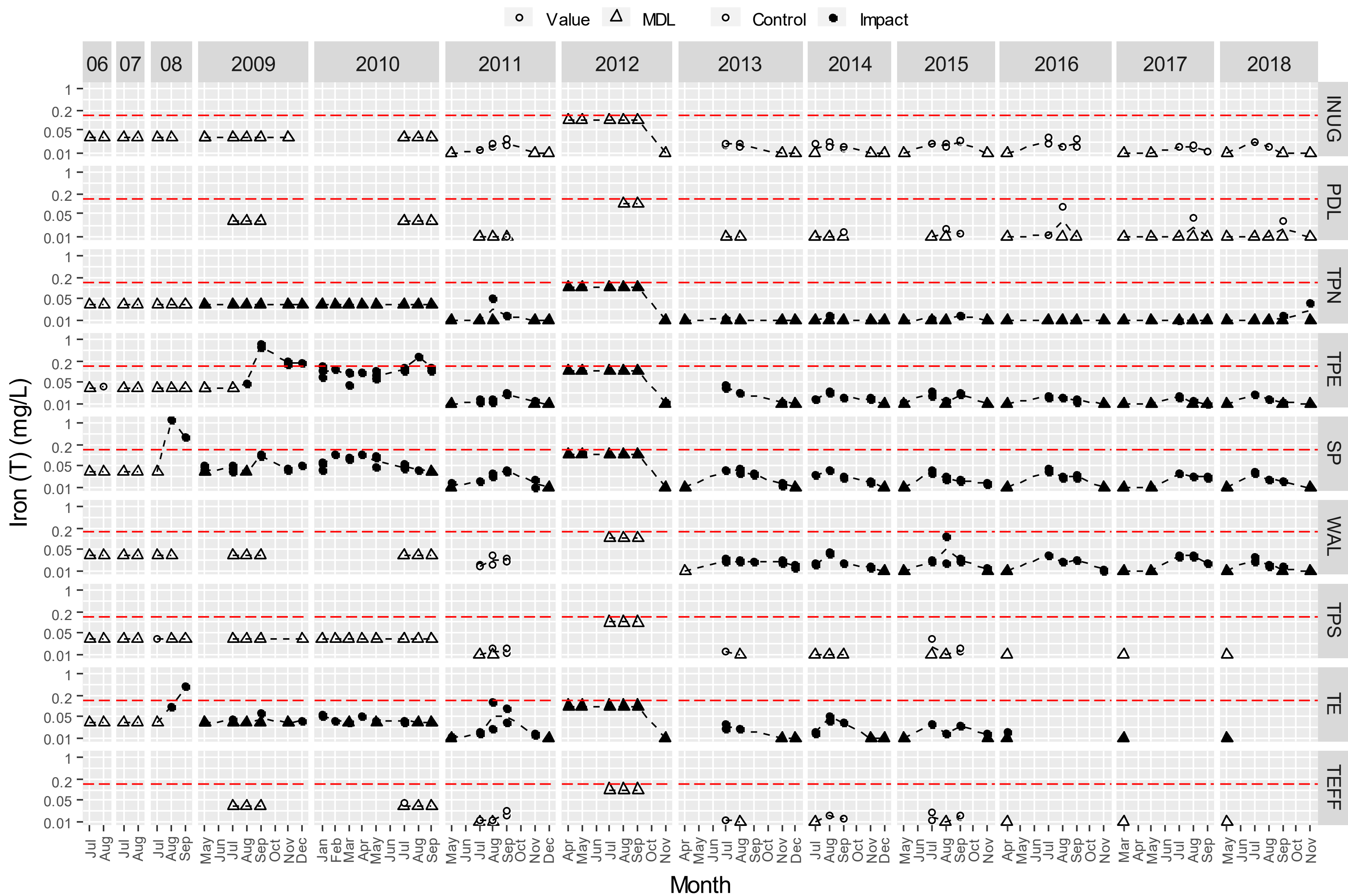


Figure 4-38. Total magnesium (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

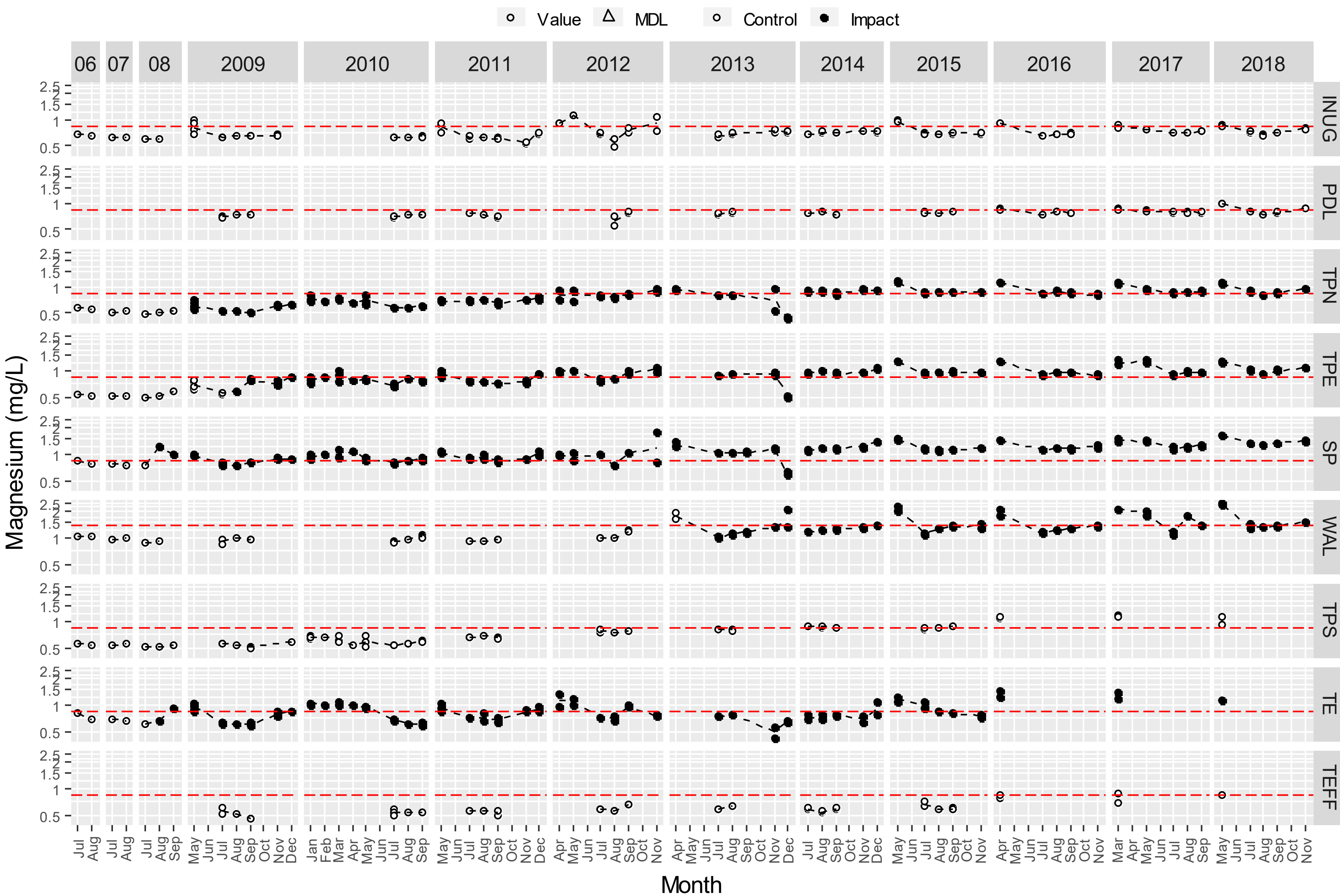


Figure 4-39. Total manganese (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

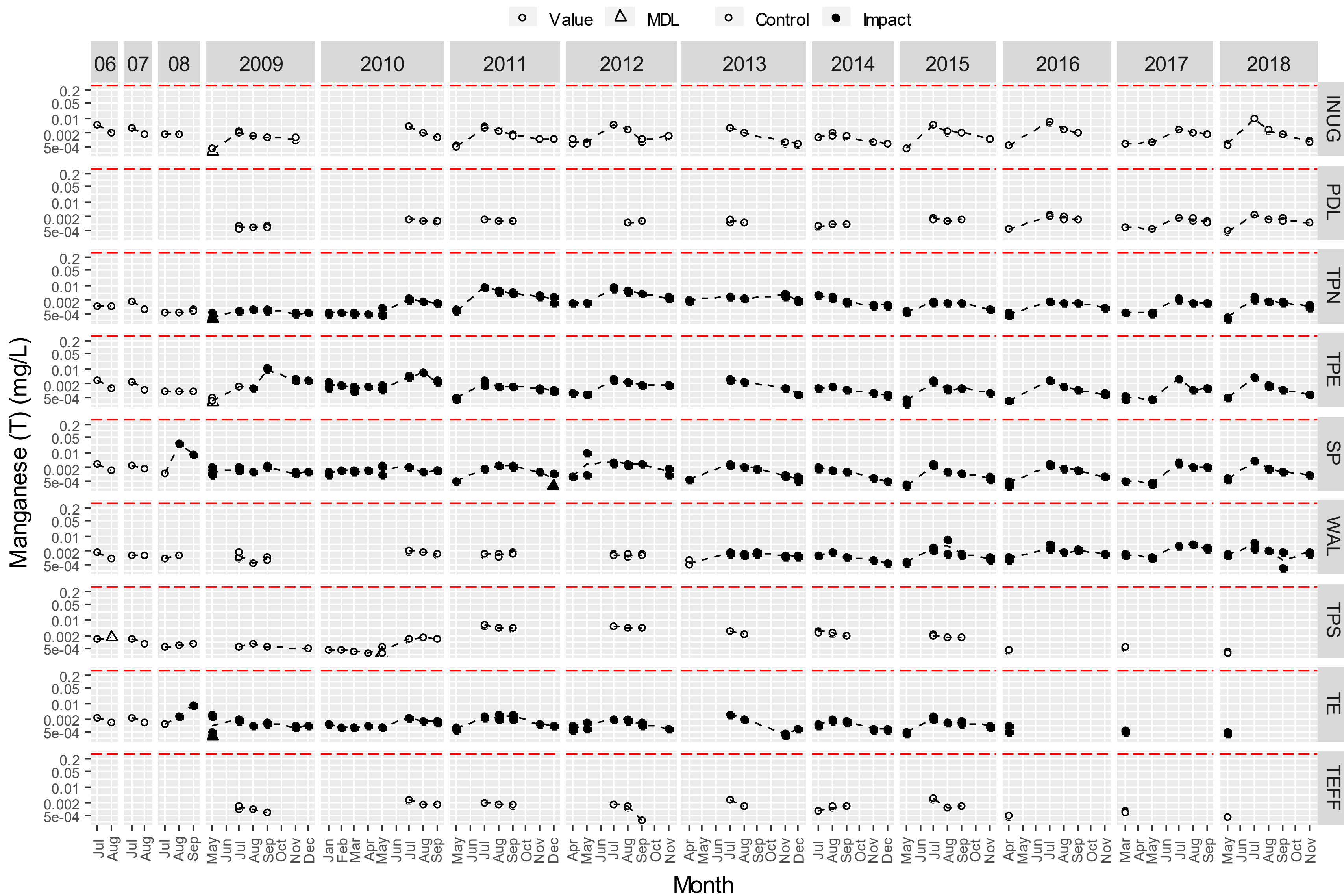


Figure 4-40. Total molybdenum (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

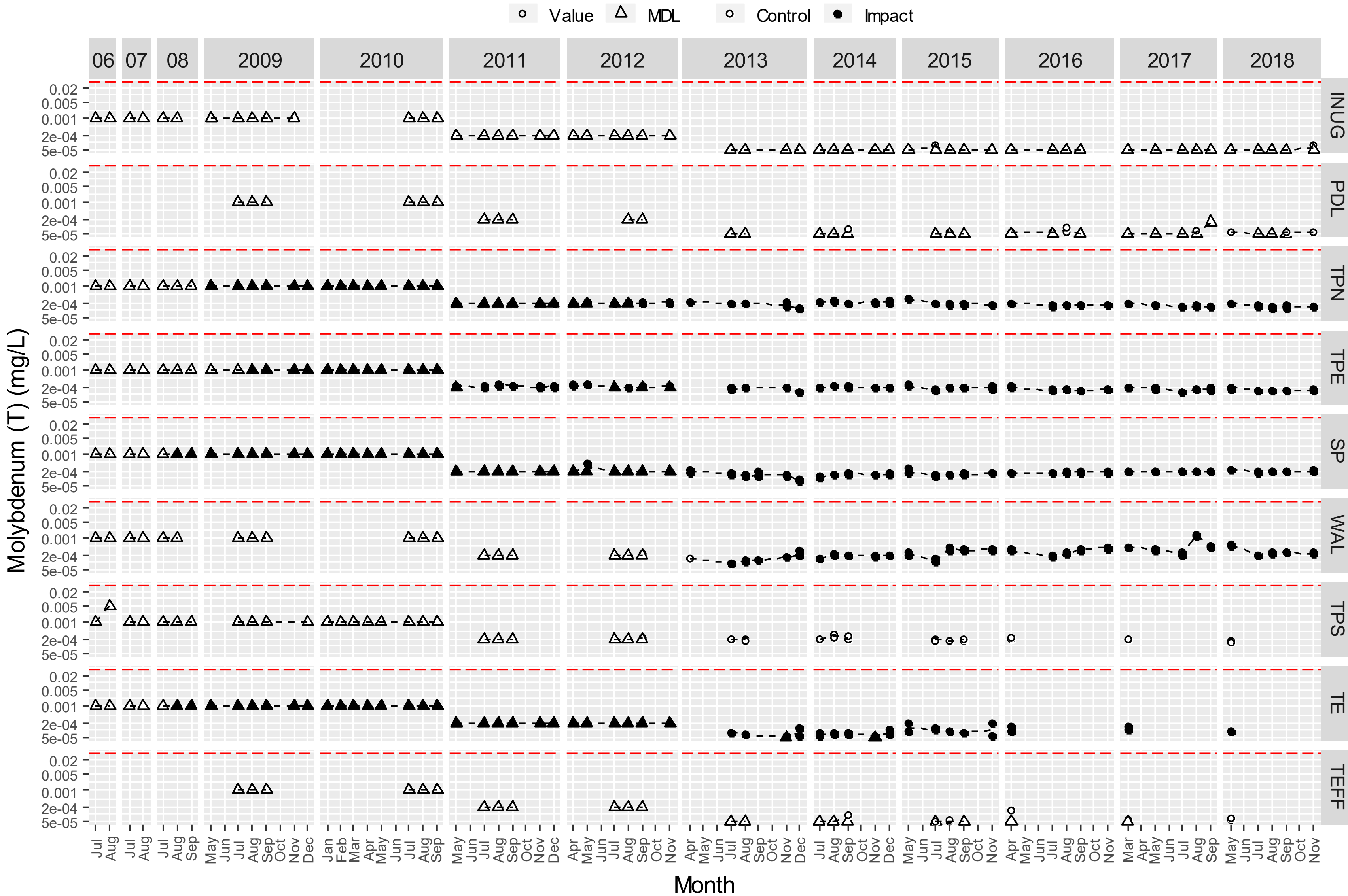


Figure 4-41. Total nickel (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

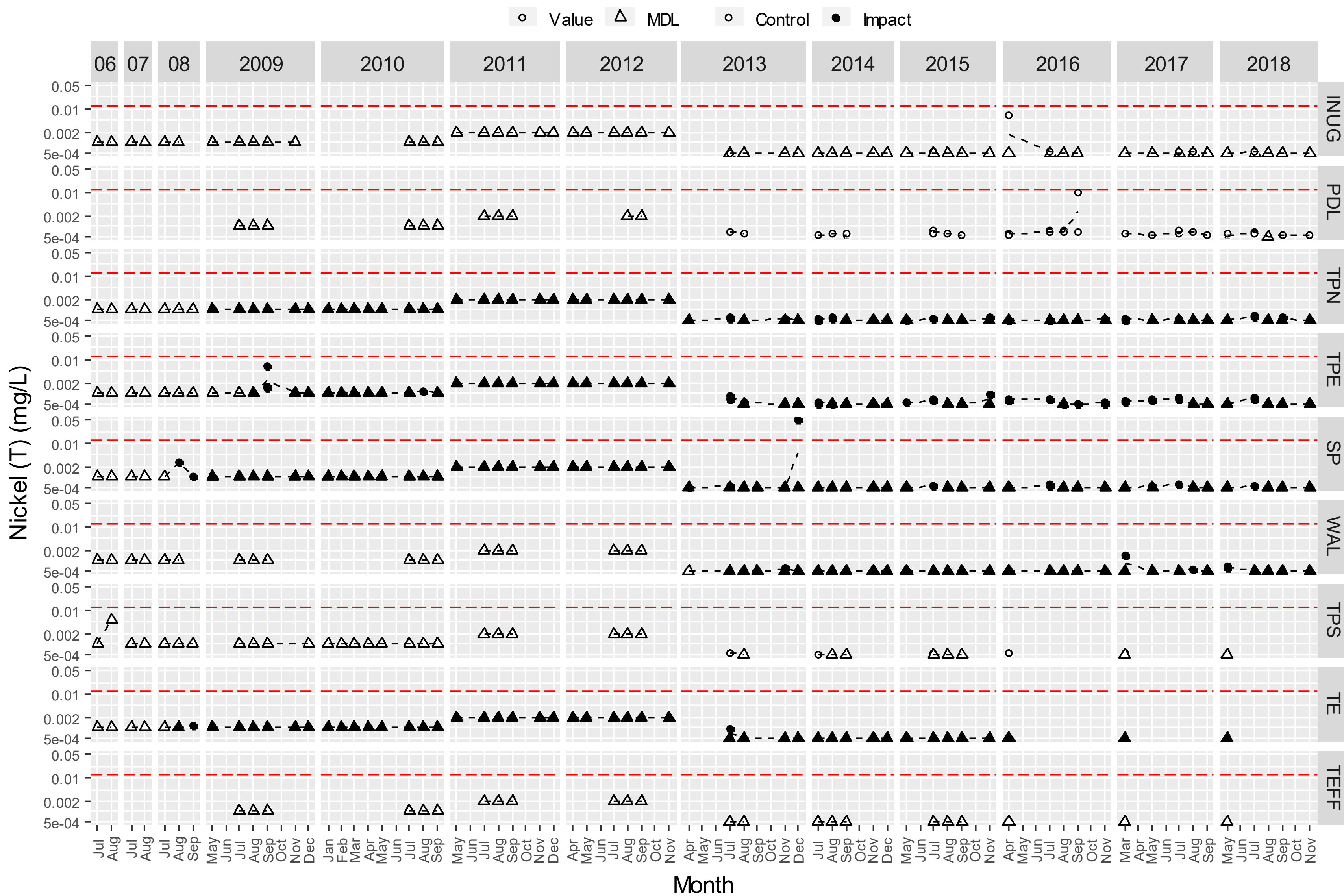


Figure 4-42. Total potassium (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

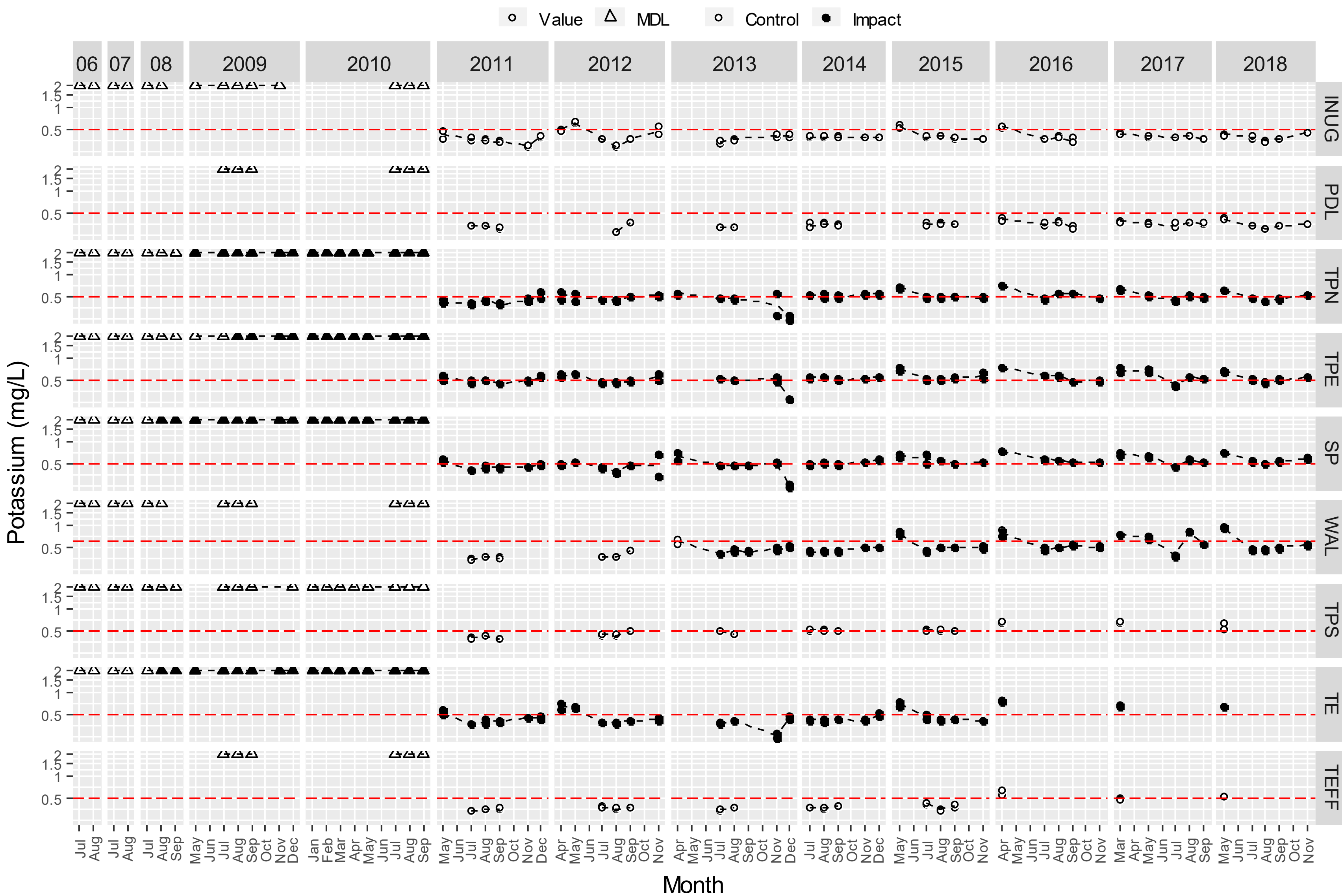


Figure 4-43. Total sodium (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

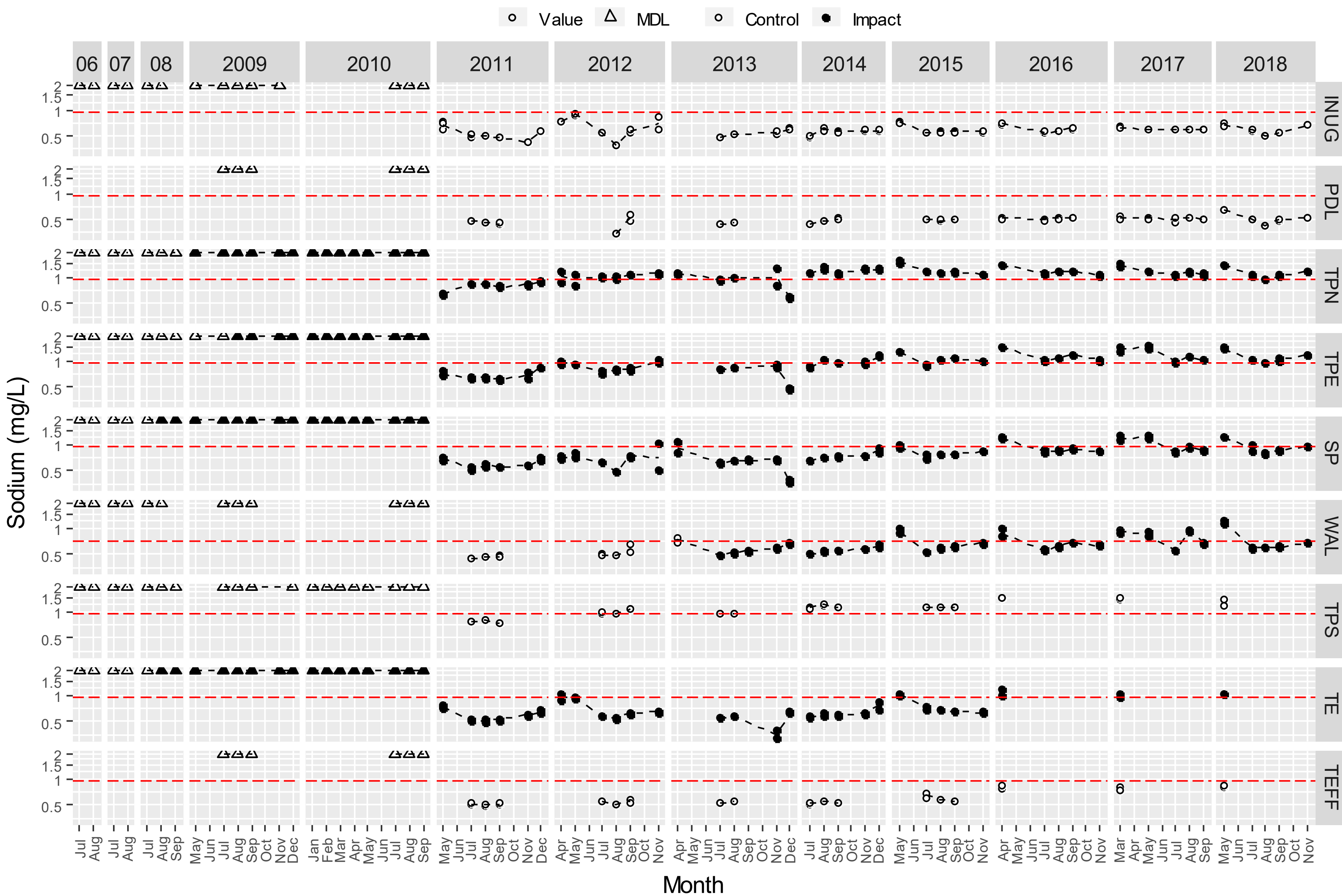


Figure 4-44. Total strontium (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

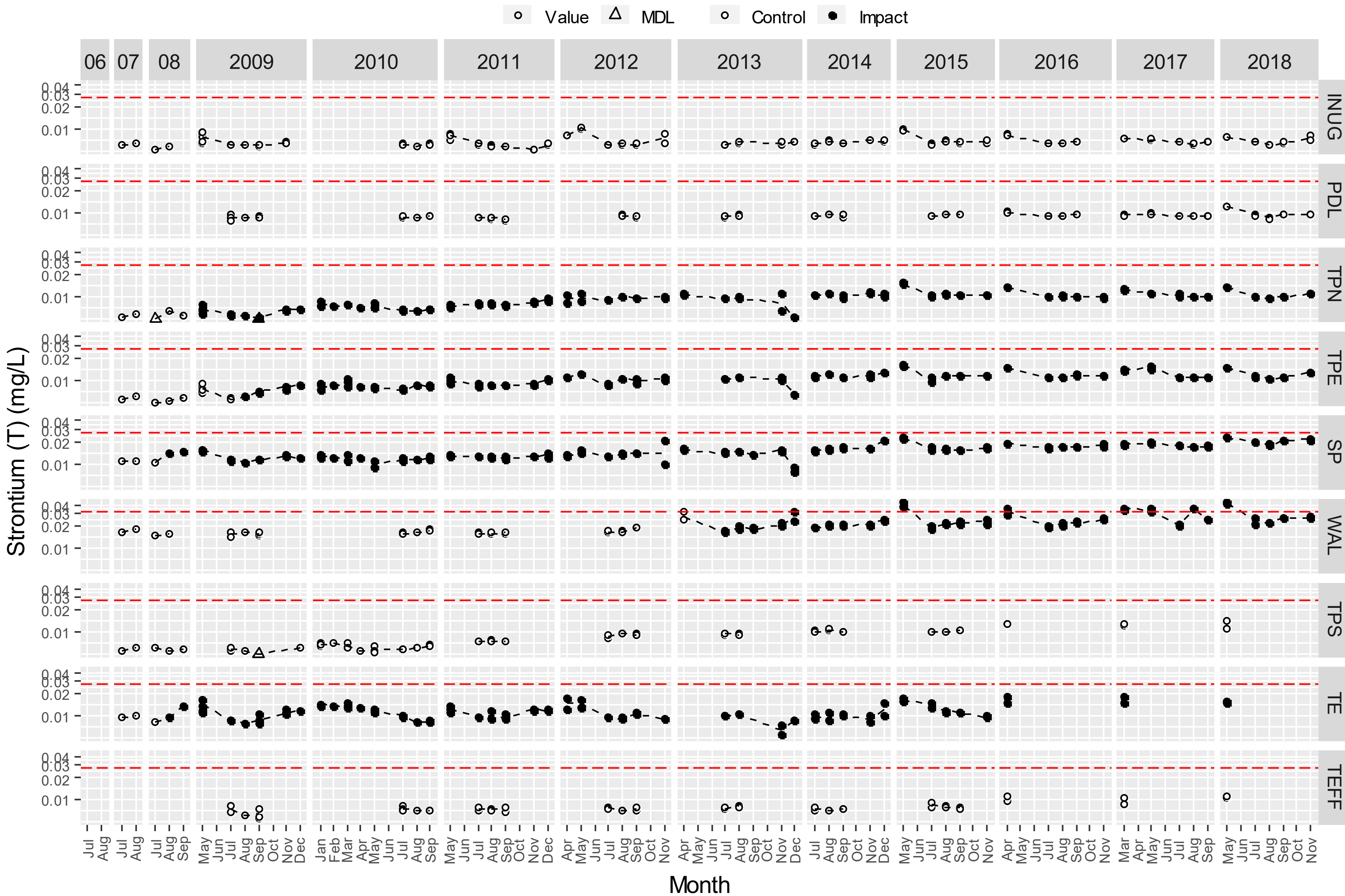


Figure 4-45. Total uranium (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

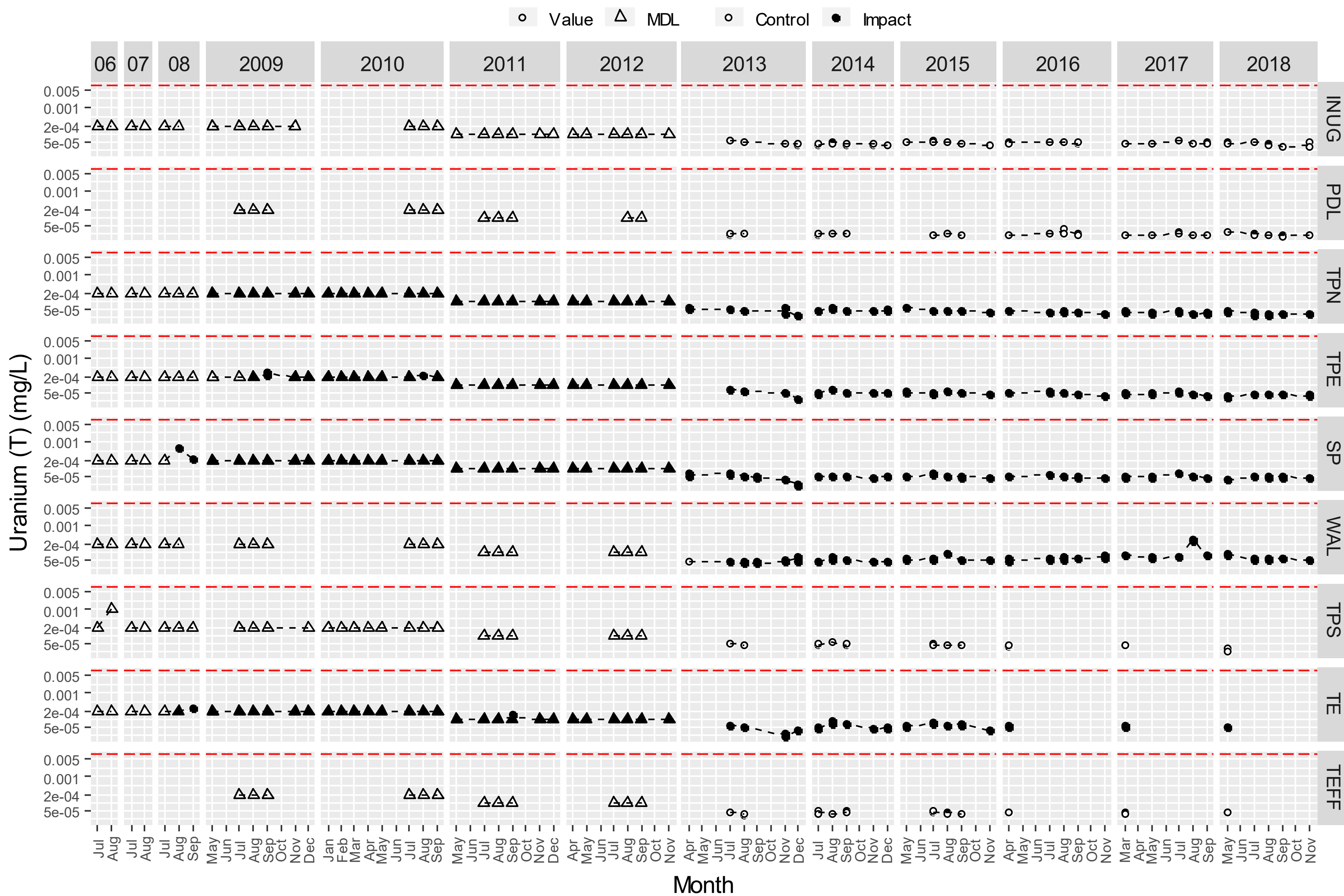


Figure 4-46. Dissolved aluminum (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

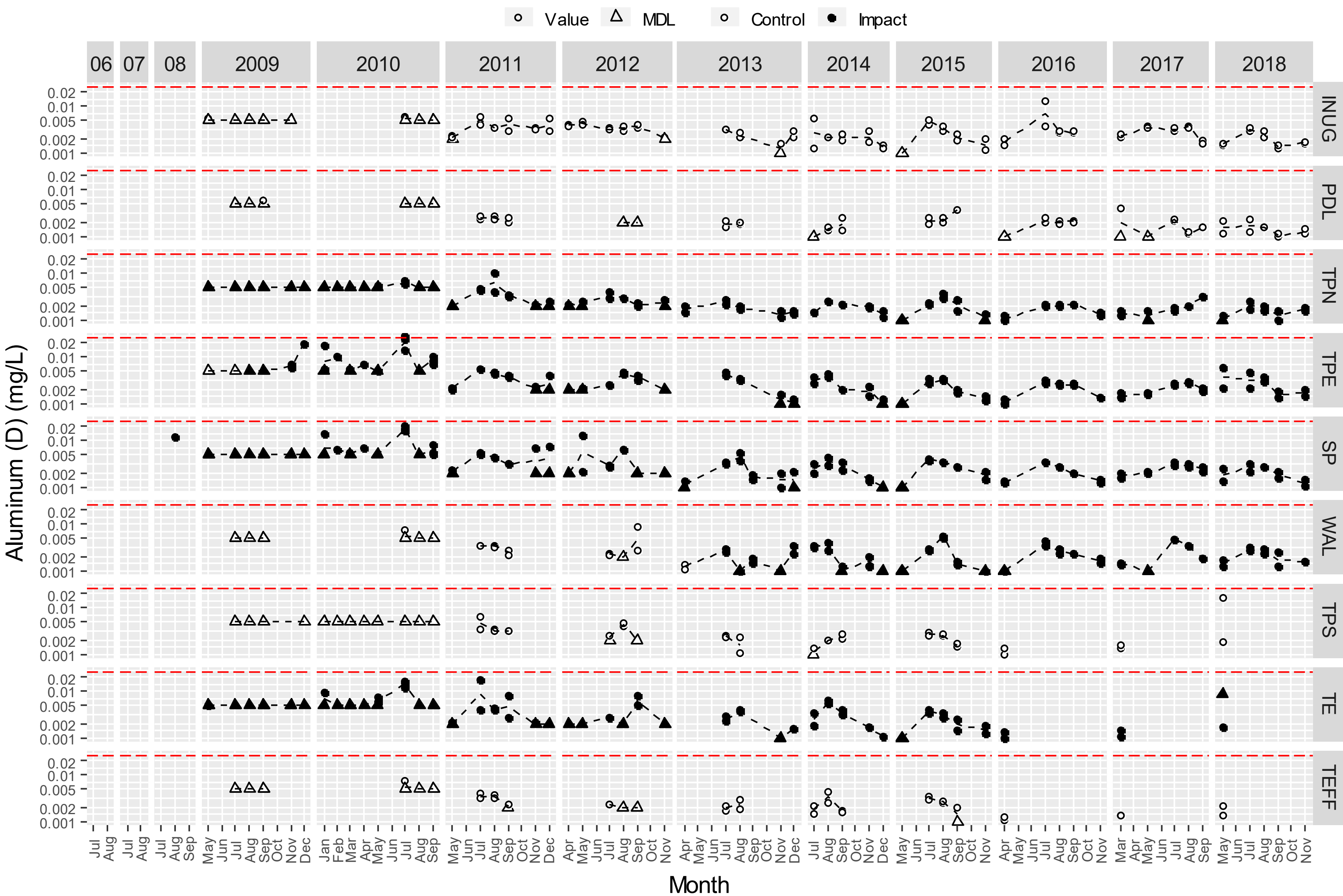


Figure 4-47. Dissolved arsenic (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

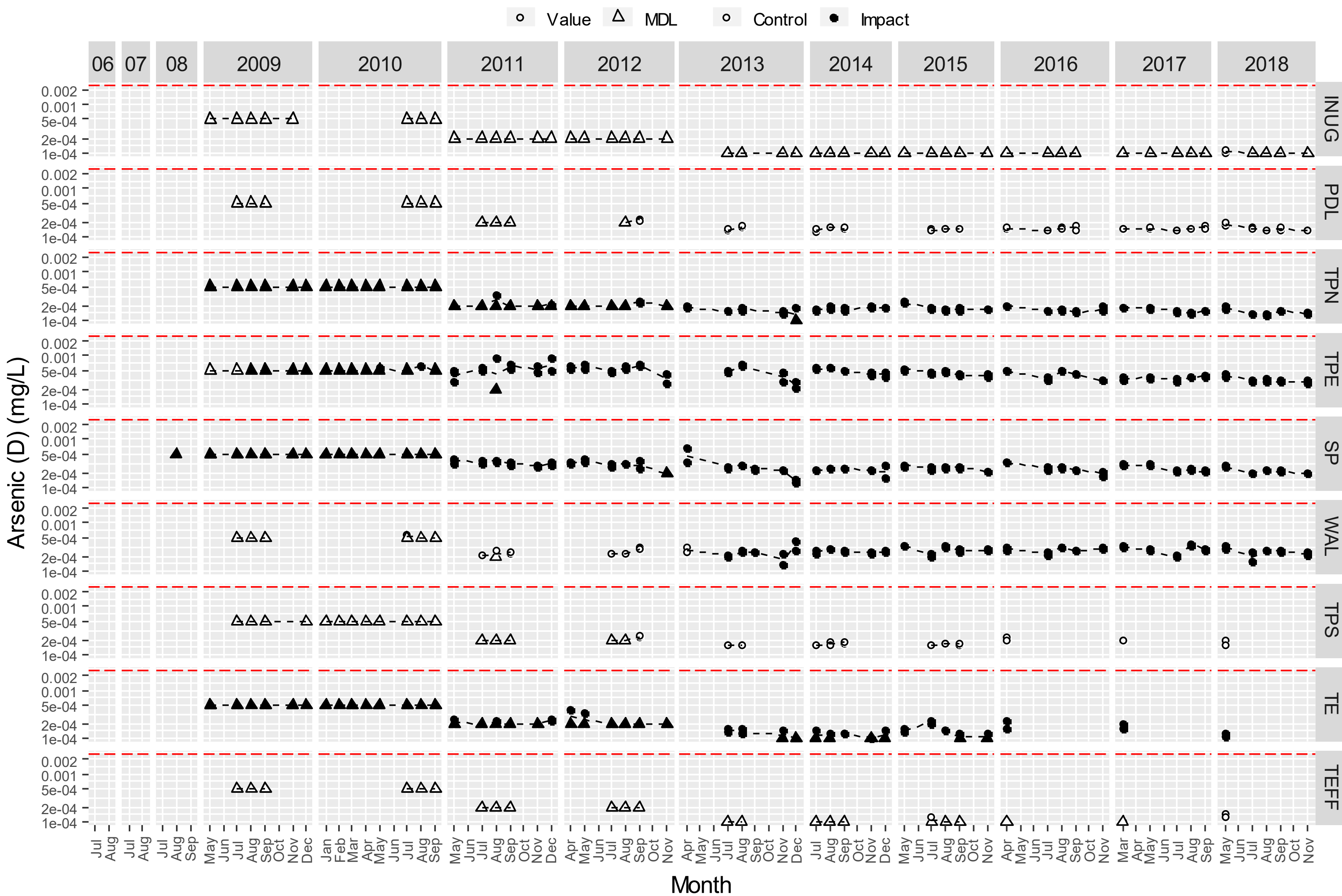


Figure 4-48. Dissolved barium (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

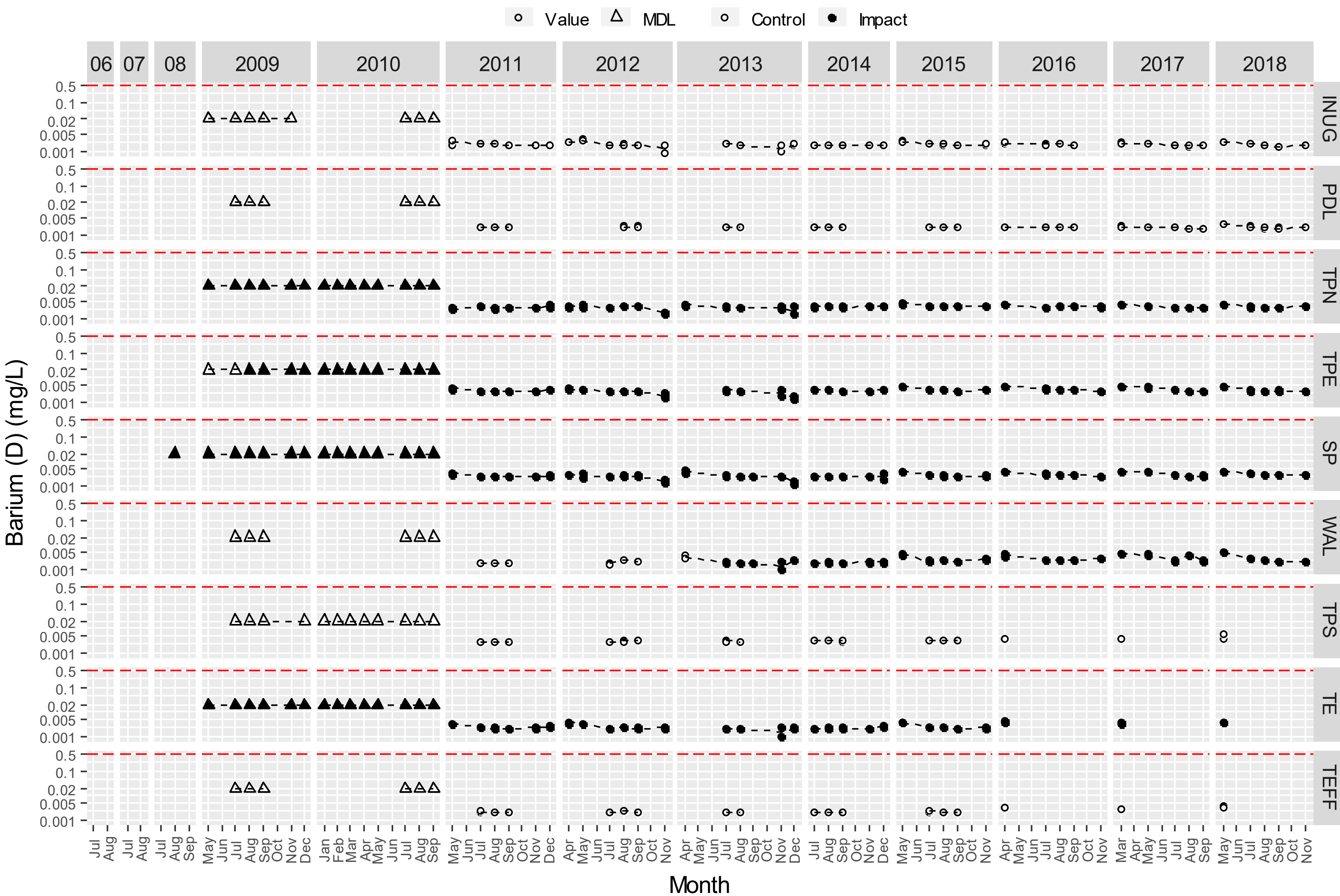


Figure 4-49. Dissolved copper (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

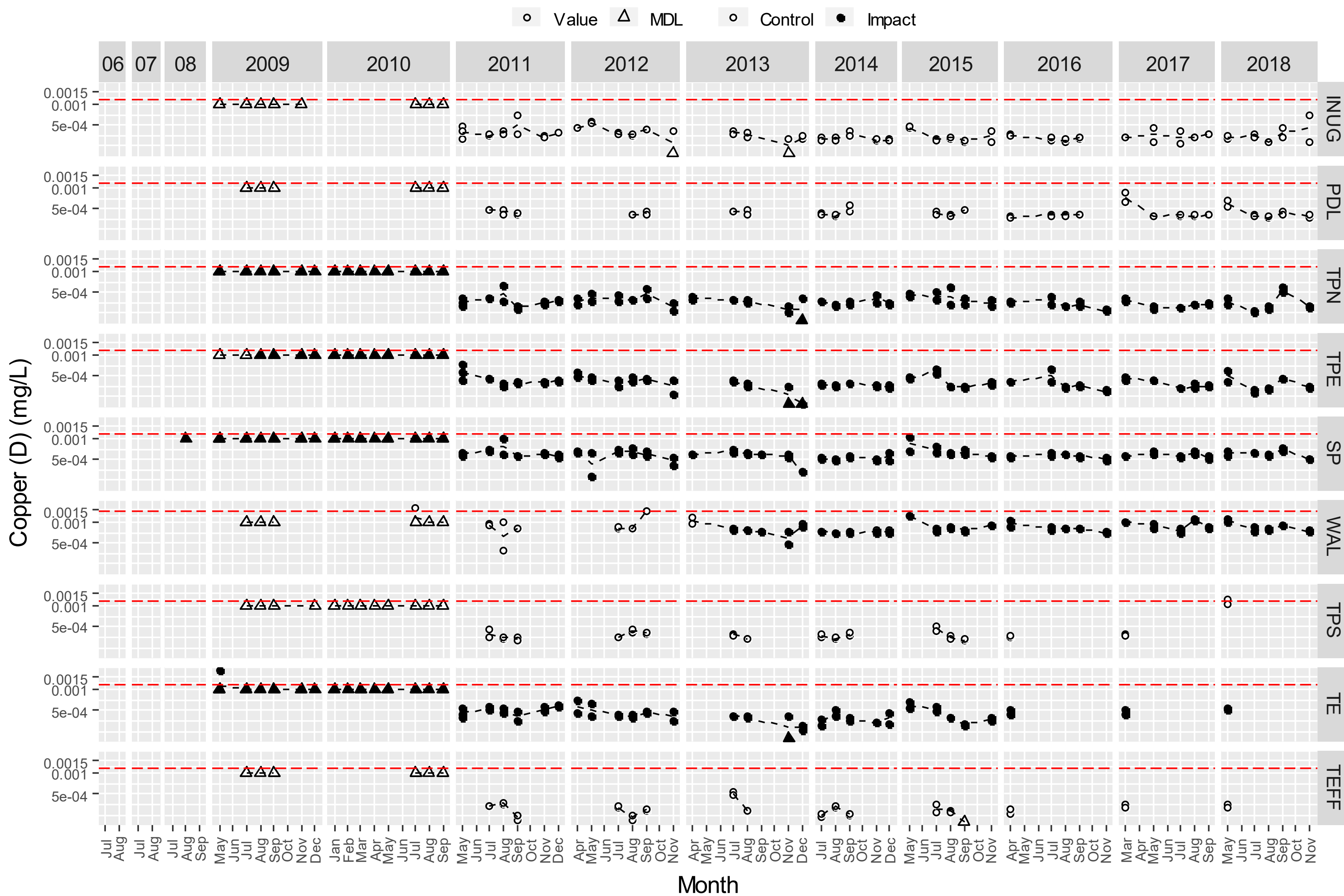


Figure 4-50. Dissolved manganese (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

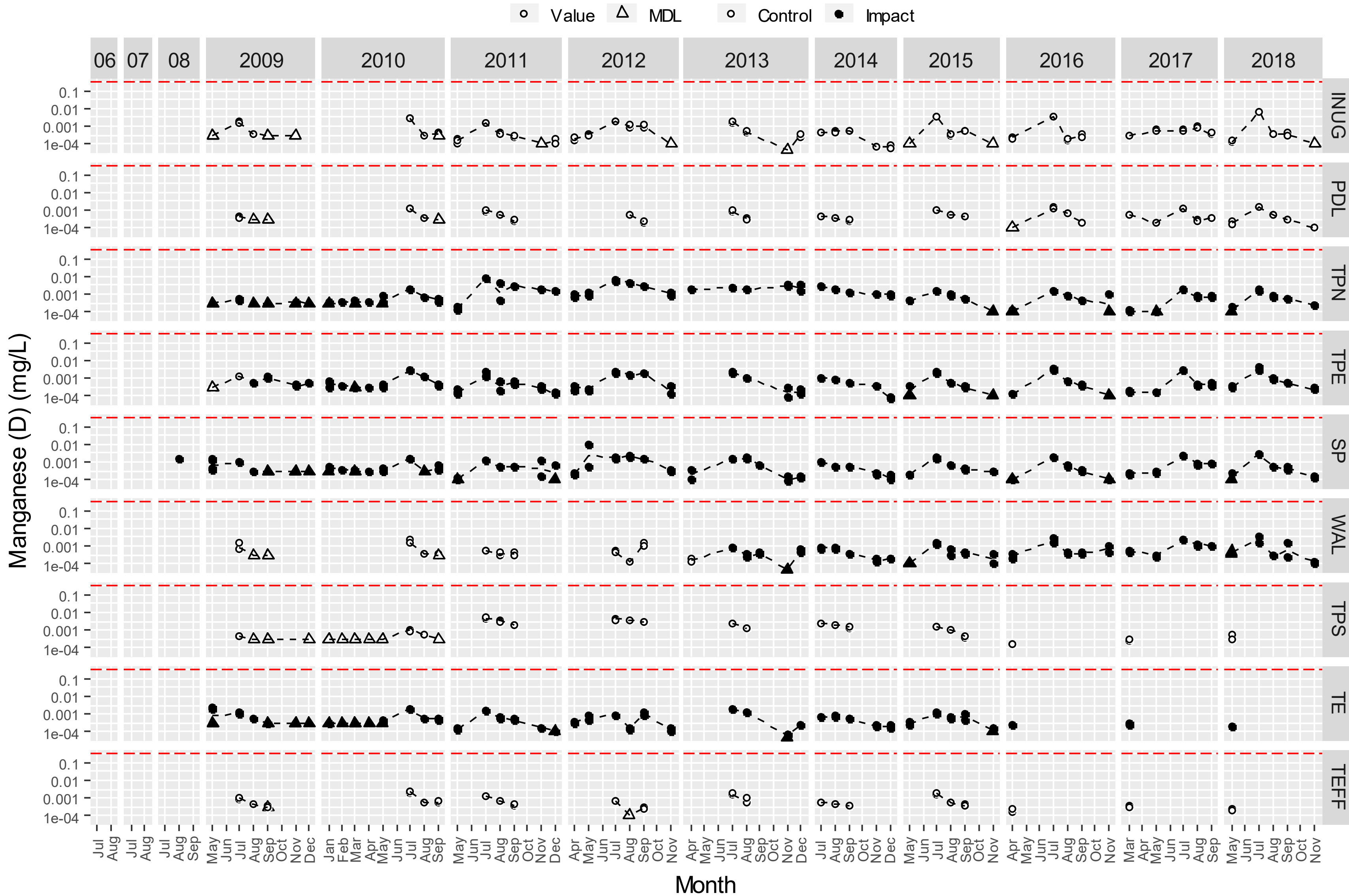


Figure 4-51. Dissolved molybdenum (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

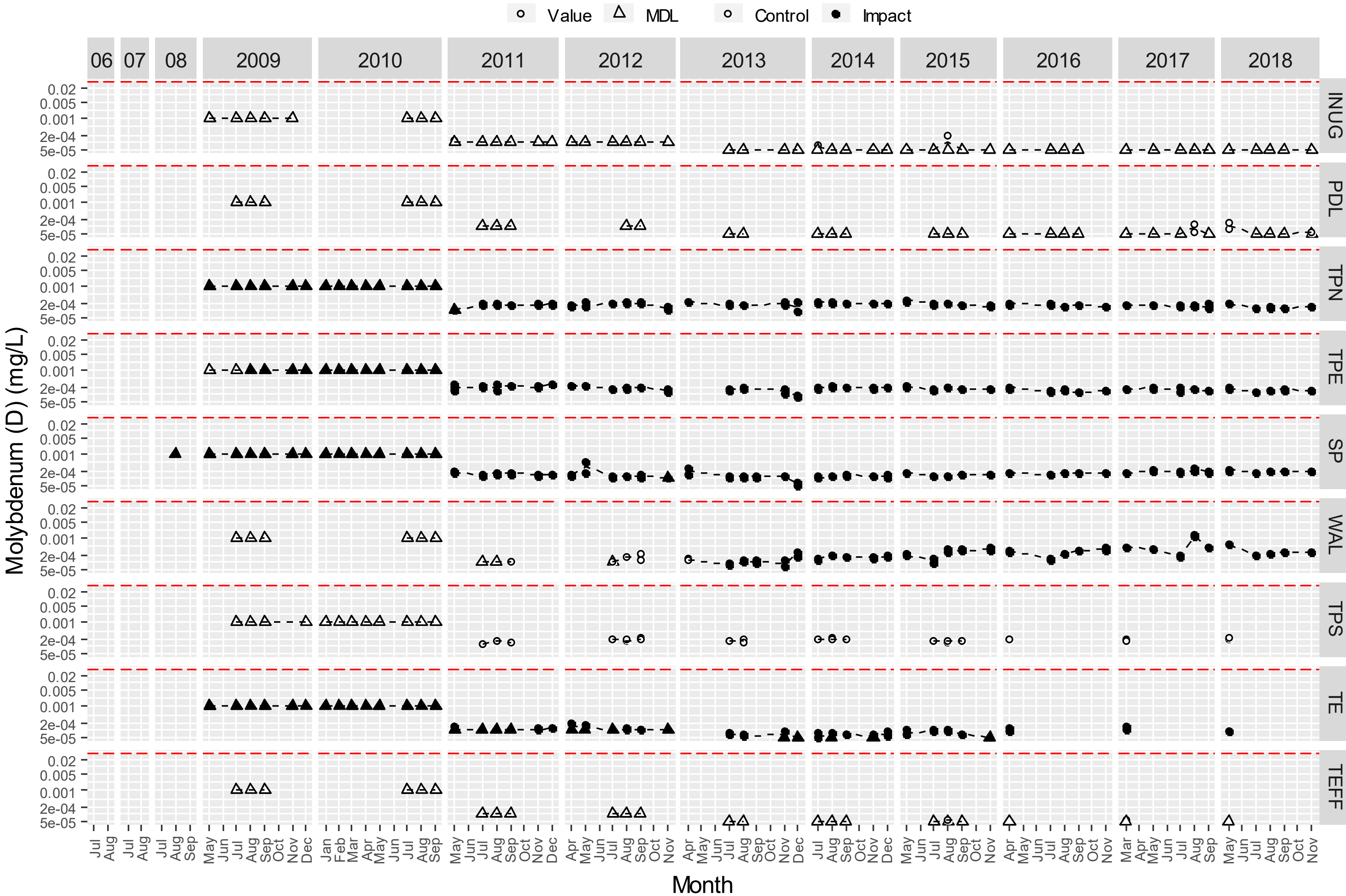


Figure 4-52. Dissolved strontium (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.

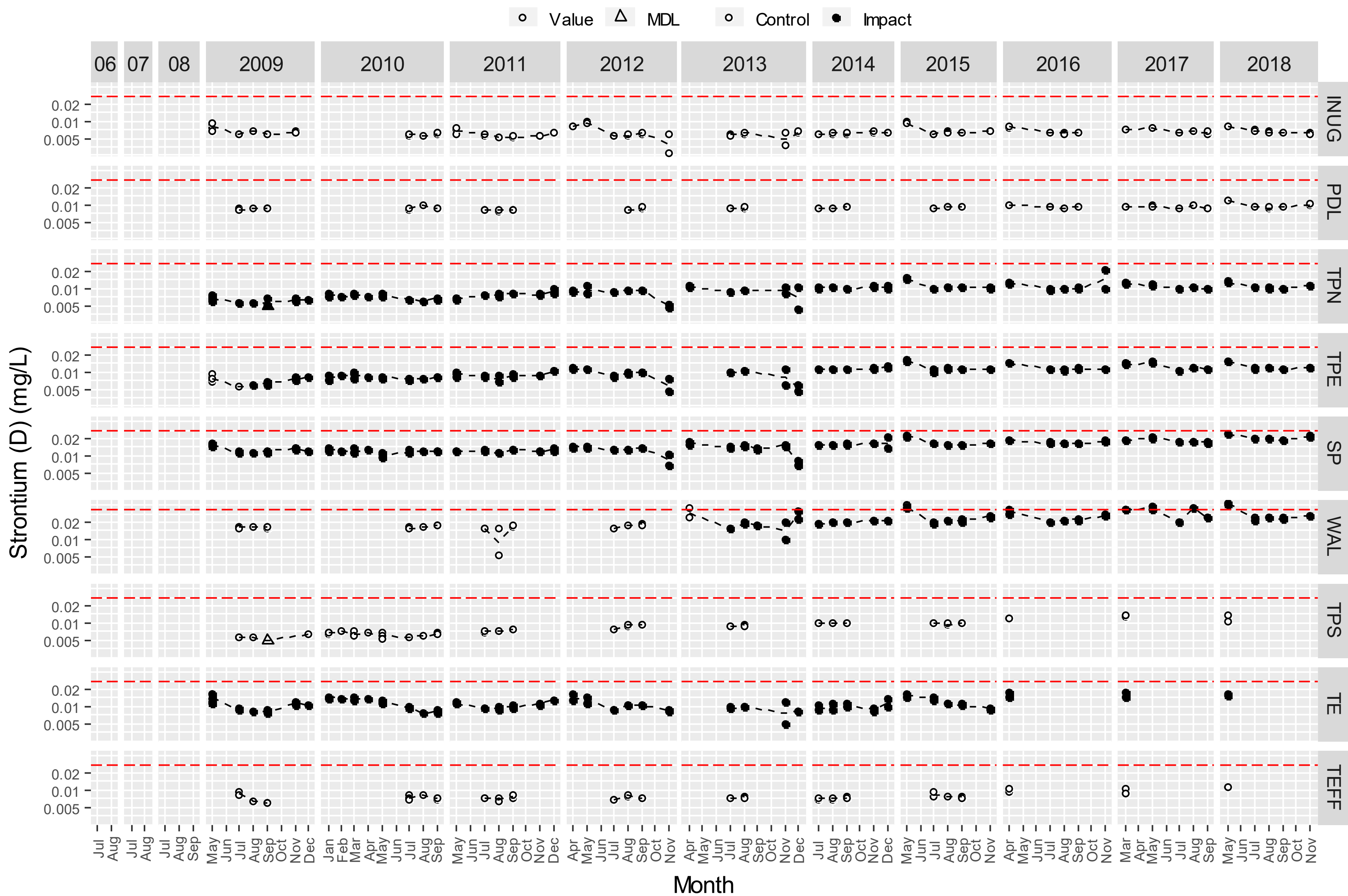
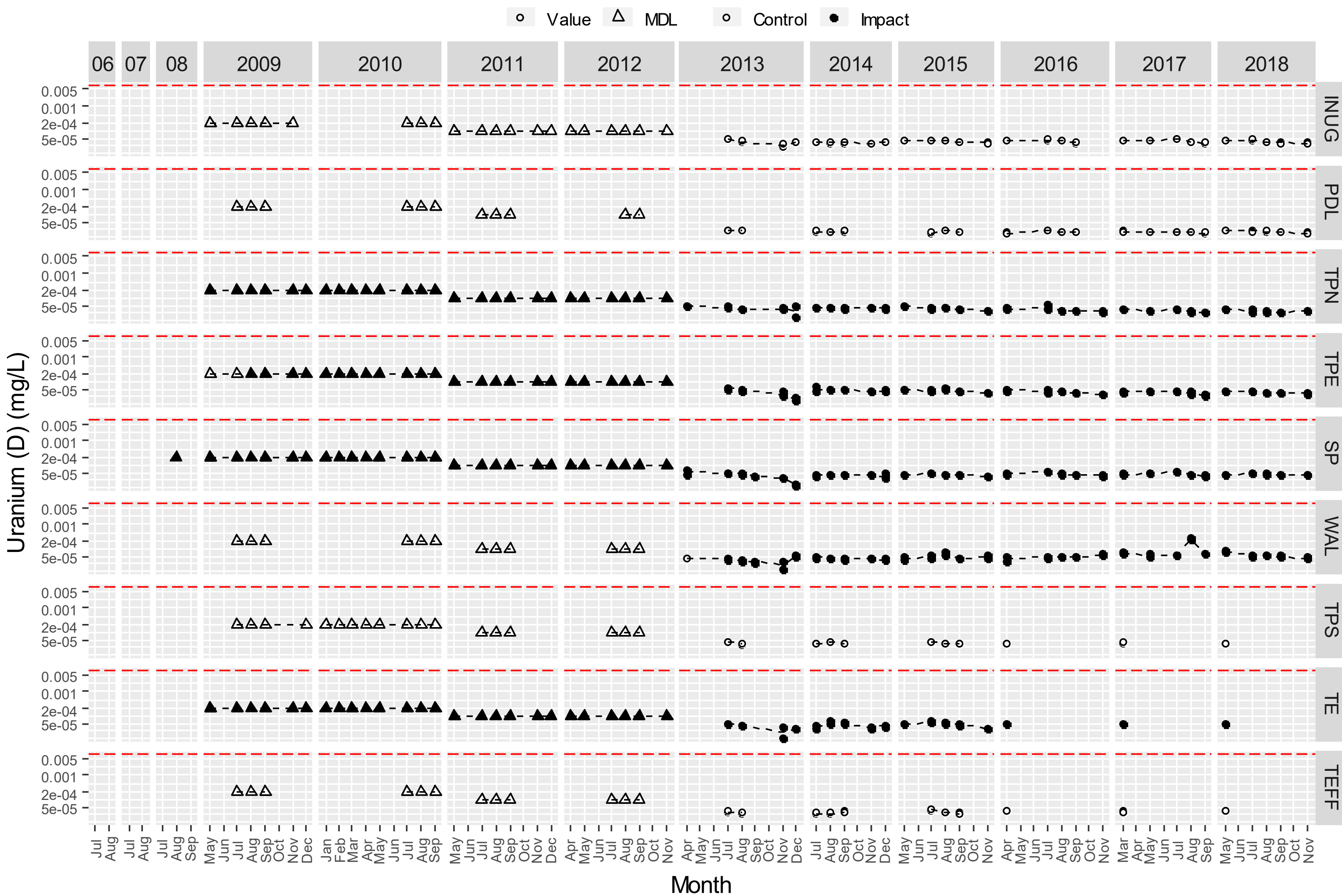


Figure 4-53. Dissolved uranium (mg/L) in water samples from Meadowbank study lakes since 2006.

Note: The red dashed line = trigger value.



Phytoplankton Tables and Figures

Table 4-6. Results of the BACI test for phytoplankton variables at Meadowbank areas, 2018.

Parameter Measured	Test Area	n(B)	n(A)	Estimate	SE	P-value*	Effect size (%)		
							ES	LCI	UCI
Total Biomass	TPN	7	5	0.4	0.31	0.23	49	-26	198
	TPE	8	5	0.33	0.23	0.18	39	-16	129
	SP	6	5	0.46	0.46	0.17	58	-21	217
	WAL	19	5	0.45	0.45	**0.048**	56	0	144
Taxa Richness	TPN	7	5	0.26	0.1	**0.03**	29	3	63
	TPE	8	5	0.09	0.06	0.20	9	-5	25
	SP	6	5	0.16	0.11	0.19	18	-9	52
	WAL	19	5	0.1	0.06	0.13	10	-3	25

Notes:

* **Bolded** values are P-values < 0.1

Shaded cells indicate positive (increases) or negative (reduced) effect sizes of 20% or more

Test area = area compared to control (INUG)

n(B) = number of months in the "before" period

n(A) = number of months in the "after" period (i.e., in 2018)

Estimate = BACI model estimate of the 2018 change in mean for log-transformed data

SE = standard error of the estimate

P-value = two-tailed test of the null hypothesis of no change

ES = estimated effect size (i.e., 100%*(exp[Estimate]-1))

LCI = lower 95% confidence interval; UCI = upper 95% confidence interval

Figure 4-54. Chlorophyll-a (µg/L) in water samples from Meadowbank study lakes since 2006.

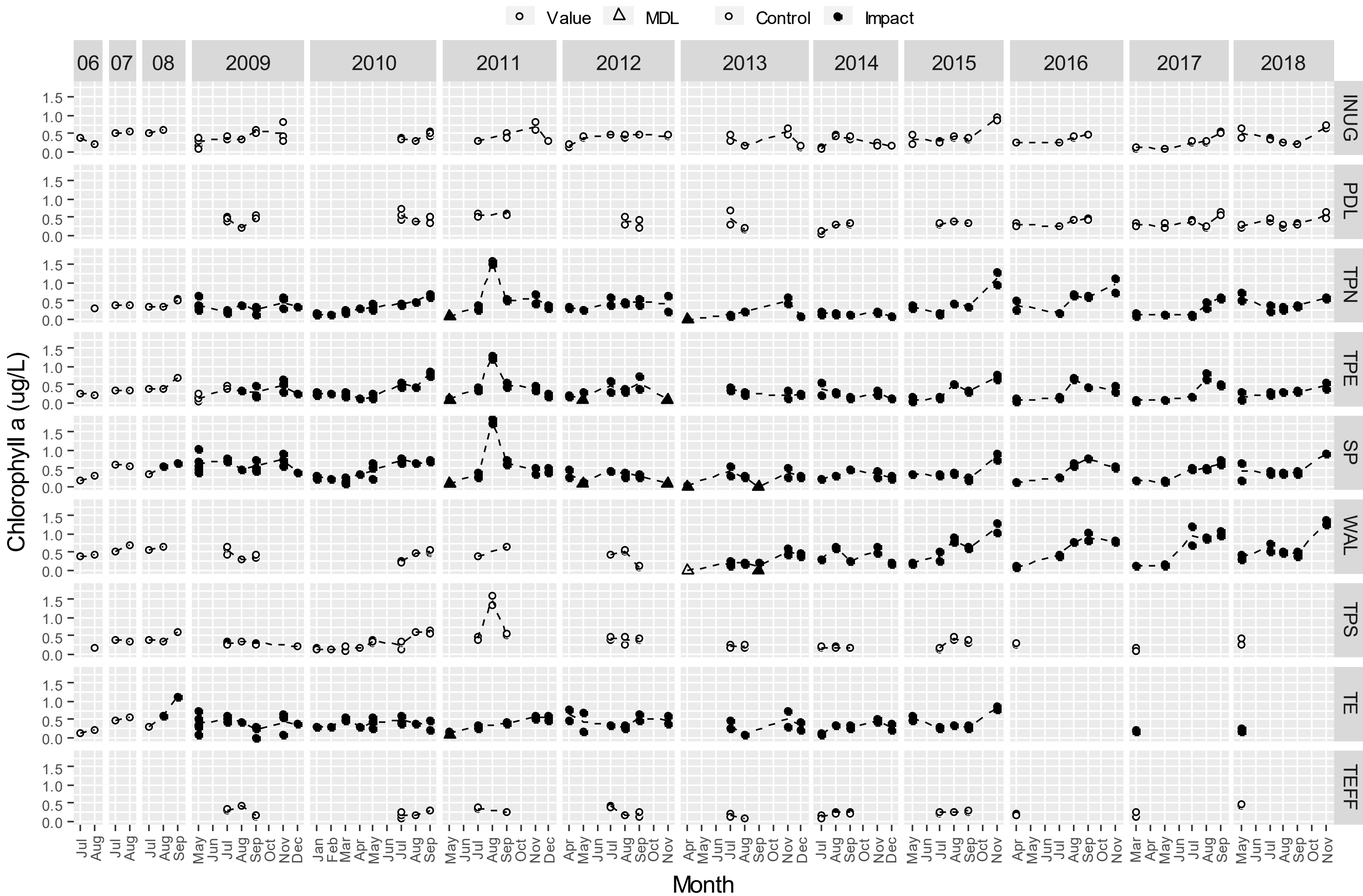


Figure 4-55. Total phytoplankton biomass (mg/m3) from Meadowbank study lakes since 2006.

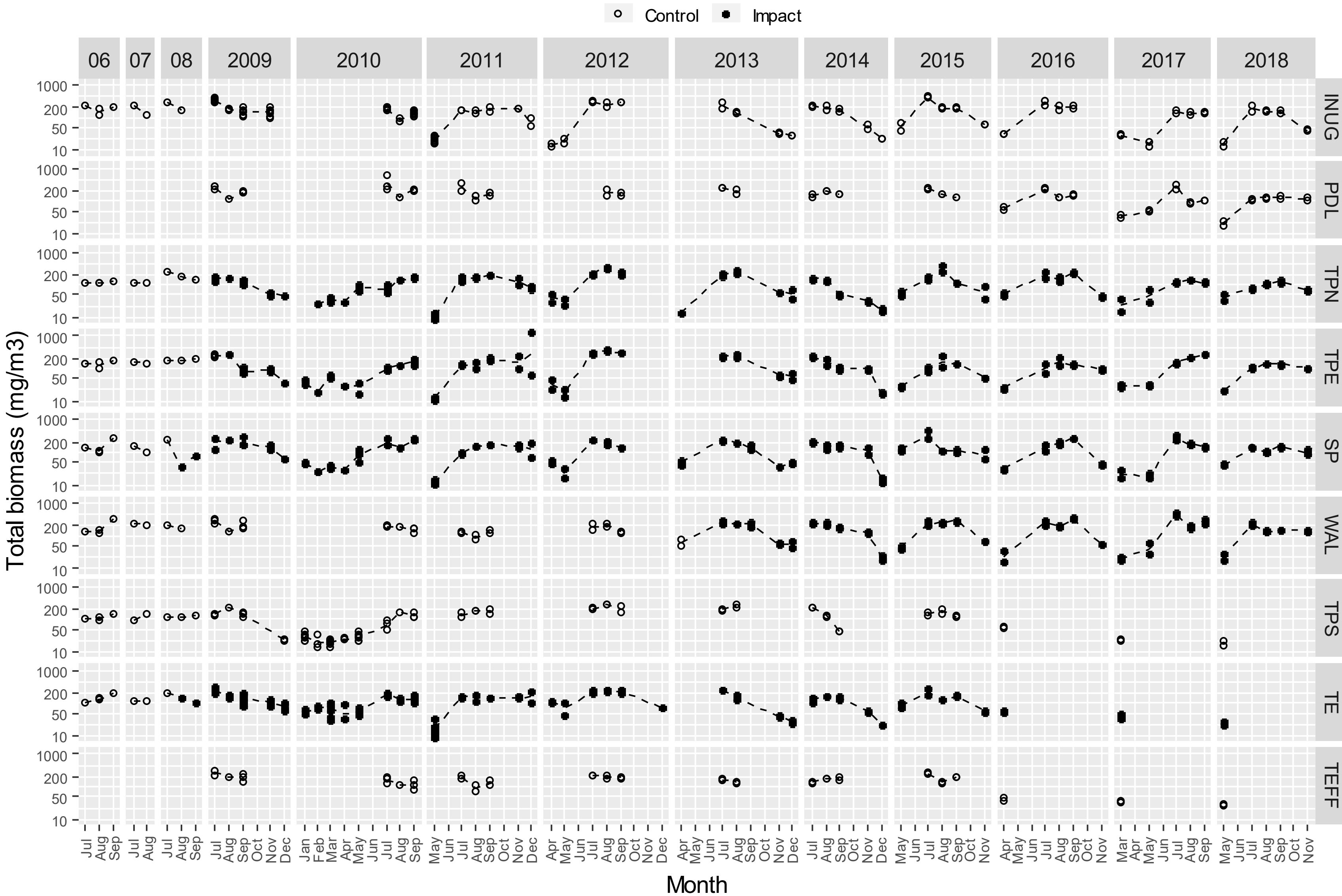


Figure 4-56. Phytoplankton biomass (mg/m3) by major taxa group from Meadowbank study lakes since 2006.

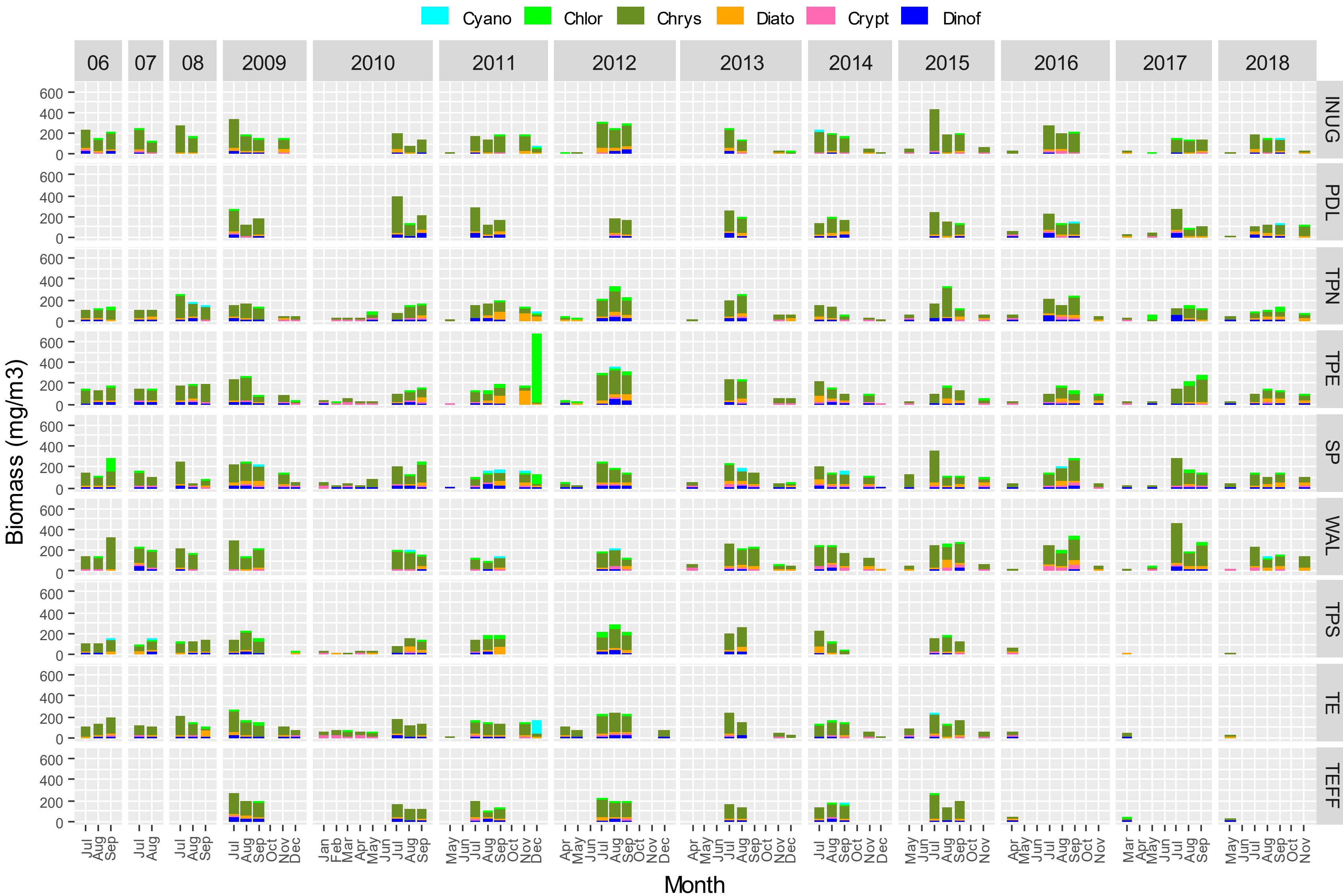


Figure 4-57. Relative phytoplankton biomass by major taxa group from Meadowbank study lakes since 2006.

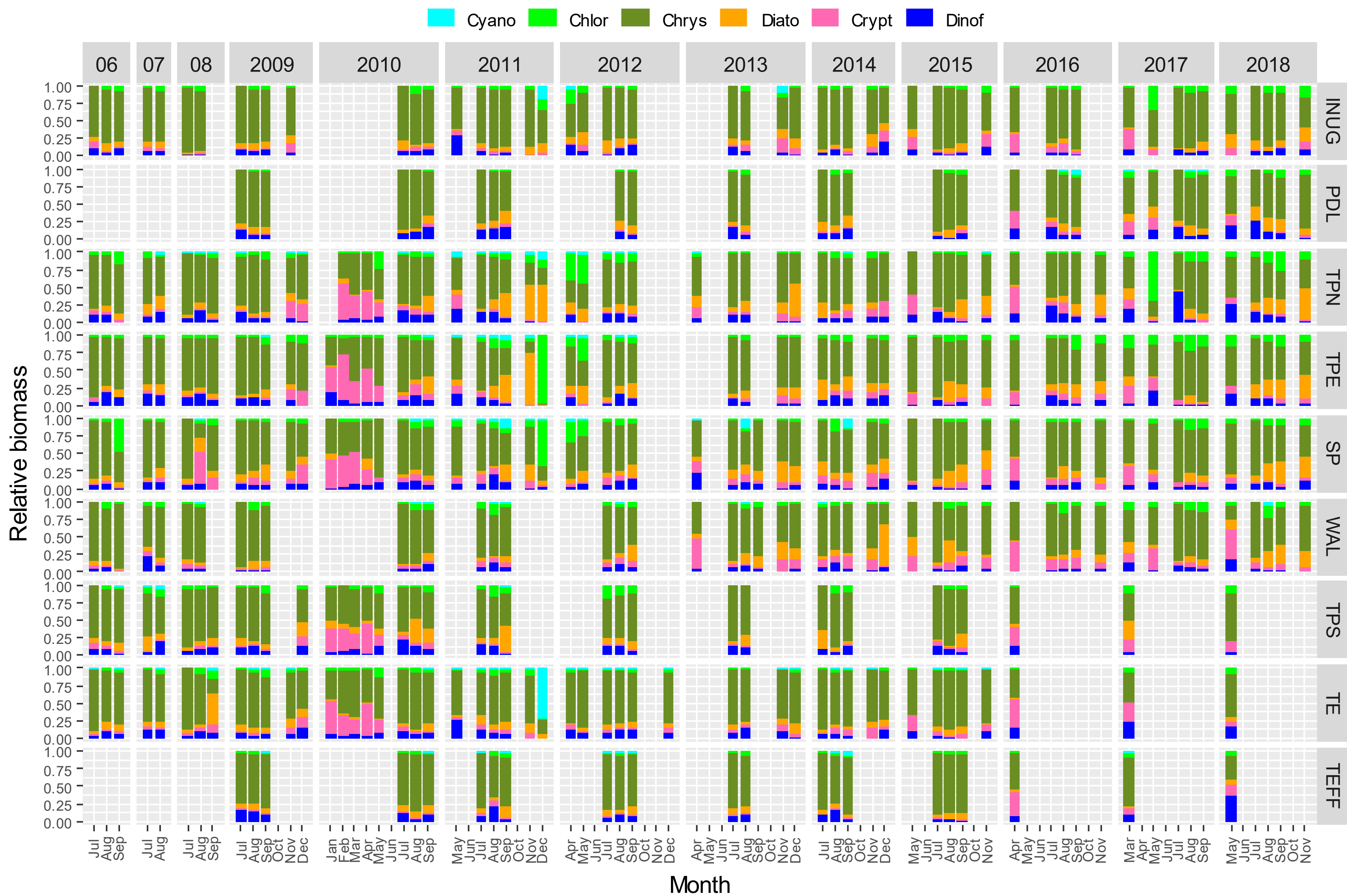
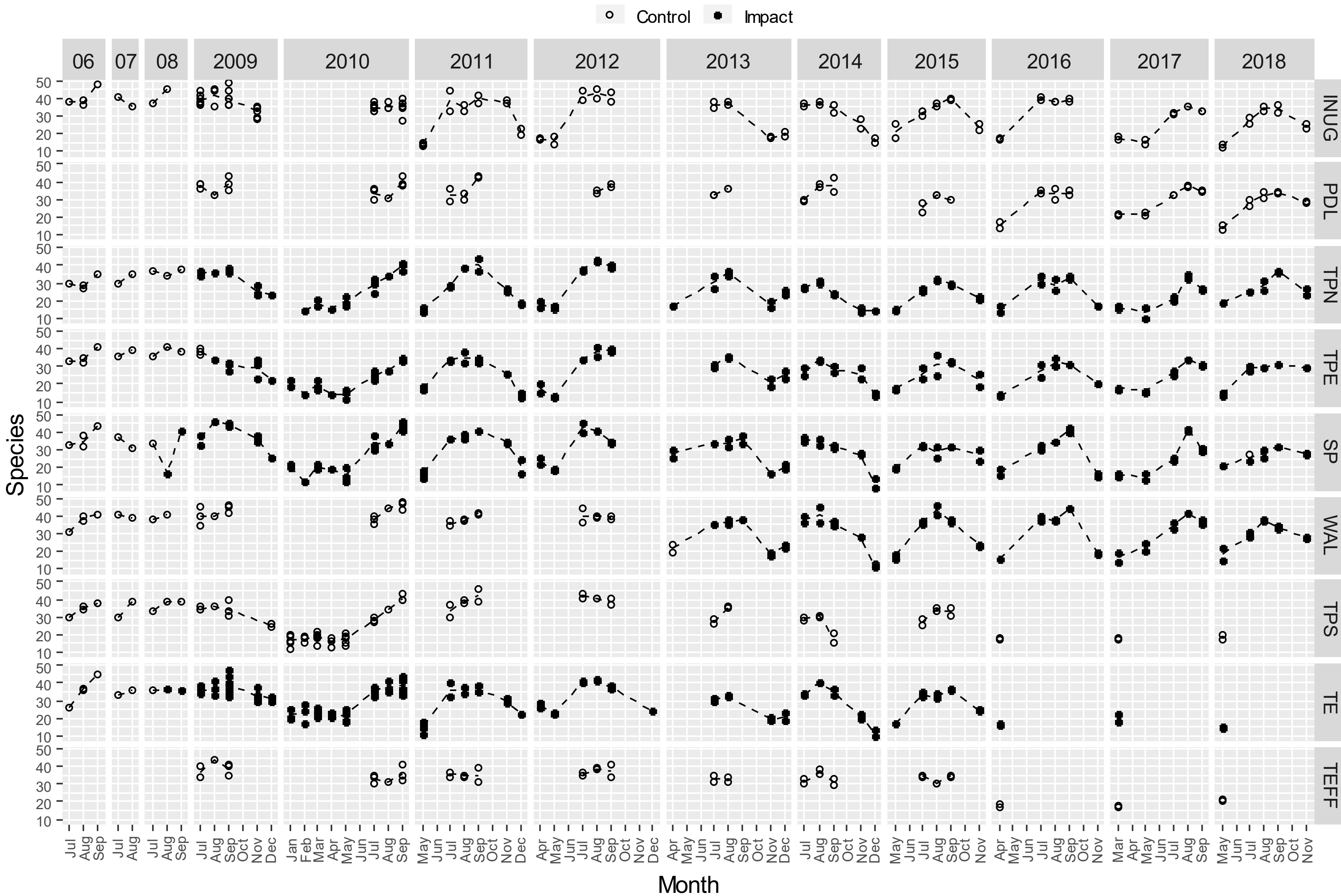


Figure 4-58. Phytoplankton species richness from Meadowbank study lakes since 2006.



Sediment Chemistry Tables and Figures

Table 4-7. Mean sediment chemistry compared to the trigger values from the Meadowbank study lakes in 2017 and 2018.

Parameter	TPE			WAL		
	Trigger	2017	2018	Trigger	2017	2018
Arsenic	121			44.5	61.8	46.6
Cadmium	1.10			0.66		
Chromium	135	205	150	61.2	61.8	
Copper	83.4			257		
Lead	25.3			36.5	36.5	
Mercury	0.102			0.12		
Zinc	114.2			142.1		

Notes:
Mean concentration (mg/kg dw) of 10 replicate samples.
Blank cells indicate the trigger value was not exceeded in 2017 or 2018.

Table 4-8. Results of the before-after statistical analysis of sediment core chemistry data at Meadowbank study lakes in 2018.

Parameter	Test Area	n(B)	n(A)	Estimate	SE	P-value[1]	Proportional change		
							exp(Est)	LCI	UCI
Chromium	TPE	30	10	0.577	0.061	**0.000**	1.78	1.57	2.01
Arsenic	WAL	20	10	0.423	0.129	**0.001**	1.53	1.17	1.99

Notes:
1. Bolded values are p-values < 0.05
Test area in 2018 compared to the before period
n(B) = number of paired months in the “before” period
n(A) = number of paired months in the “after” period (i.e., in 2018)
Estimate = BA model estimate of the 2018 change in mean for log-transformed data
SE = standard error of the estimate
P-value = one-tailed test of the null hypothesis of no change or a decrease in mean concentration
Exp(Est.) = estimated proportional change
LCI = lower 95% confidence interval; UCI = upper 95% confidence interval

Figure 4-59. Sediment grain size composition in sediment samples from Meadowbank study lakes since 2008.

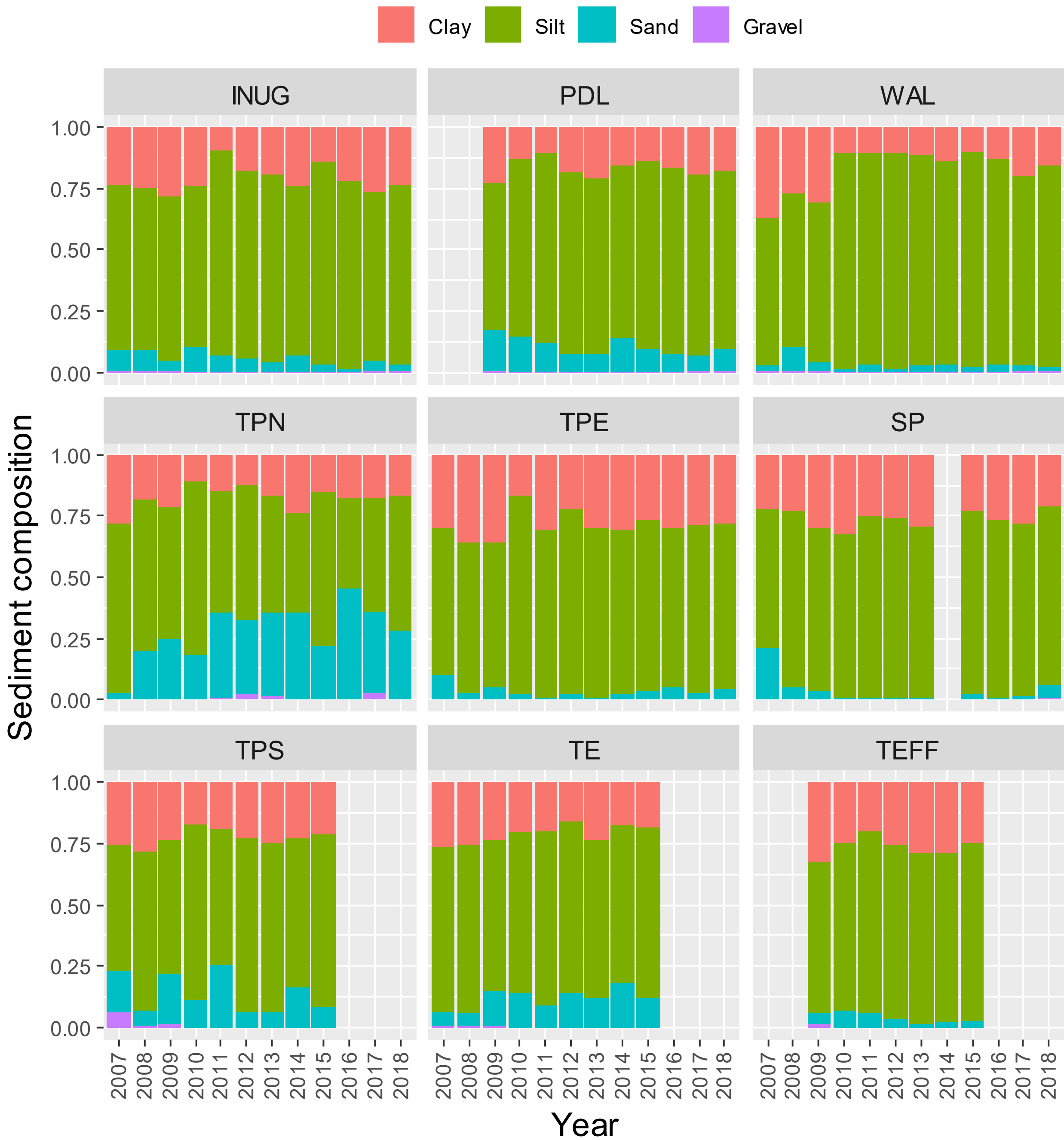


Figure 4-60. Total aluminum (mg/kg) in sediment samples (grabs & cores) from Meadowbank project lakes since 2006.

Note: Grab samples = dots; Core samples = box and whisker

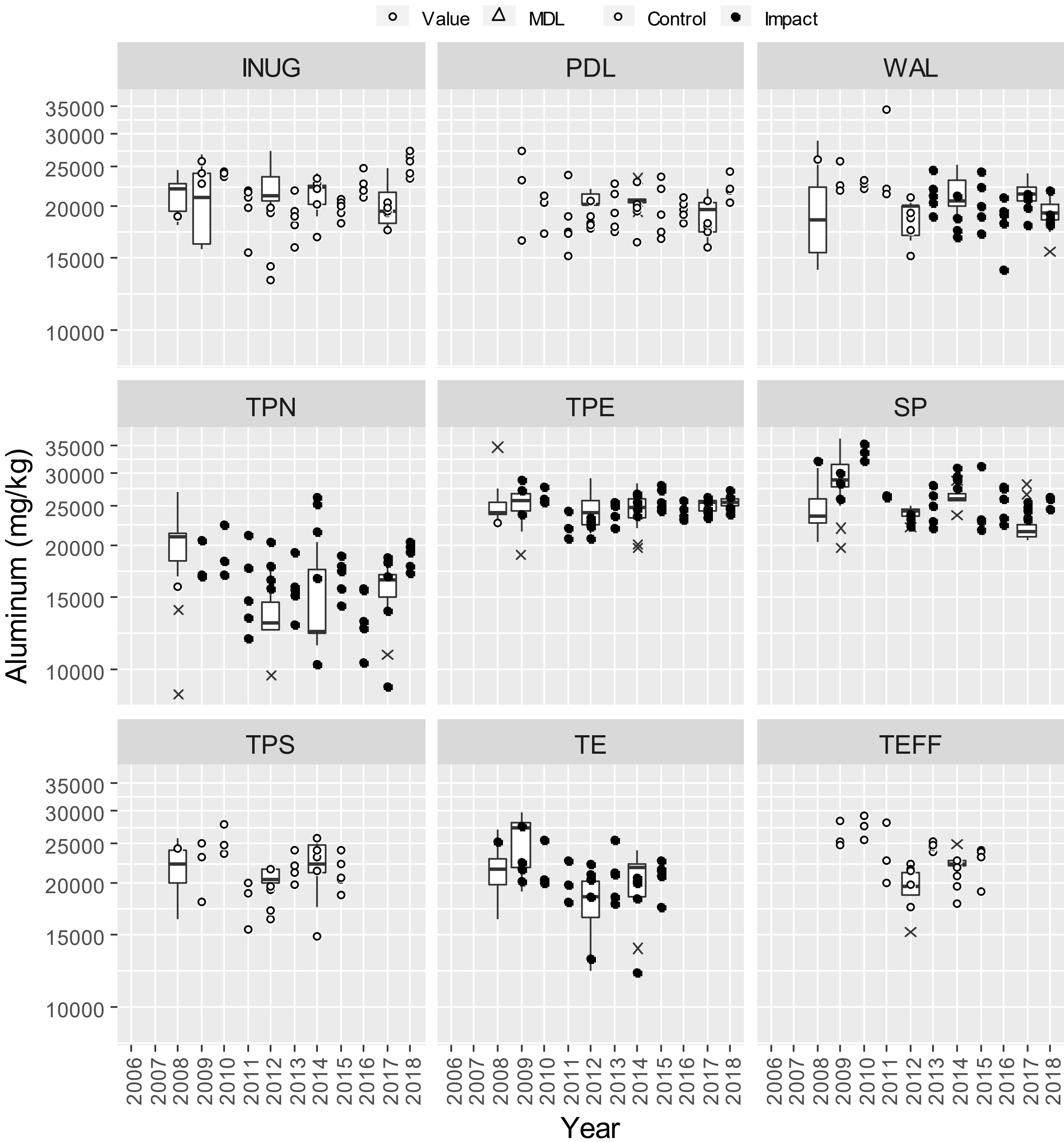


Figure 4-61. Total arsenic (mg/kg) in sediment samples (grabs & cores) from Meadowbank project lakes since 2006.

Note: Grab samples = dots; Core samples = box and whisker
The red dash line represents trigger values

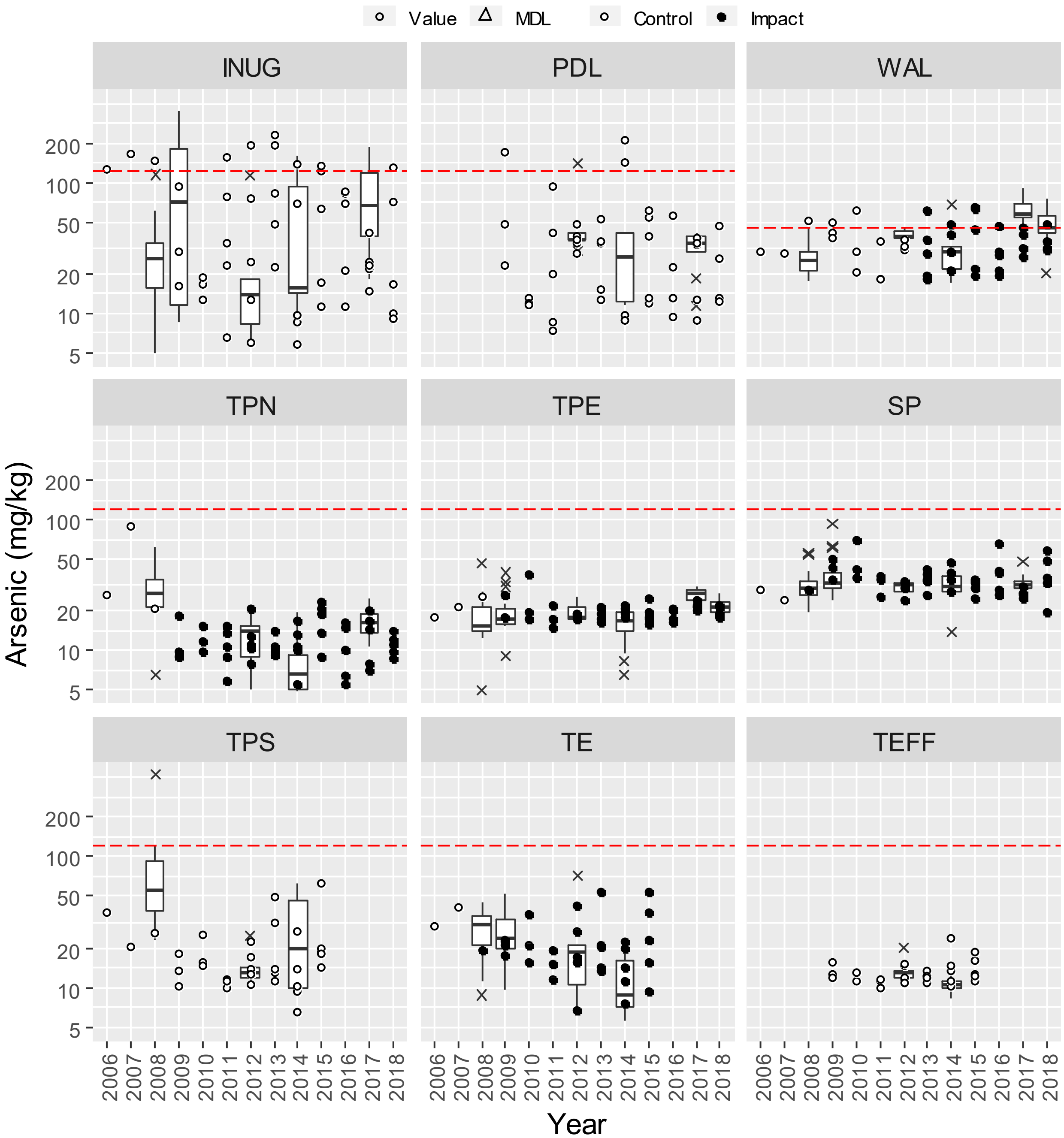


Figure 4-62. Total cadmium (mg/kg) in sediment samples (grabs & cores) from Meadowbank project lakes since 2006.

Note: Grab samples = dots; Core samples = box and whisker
The red dash line represents trigger values

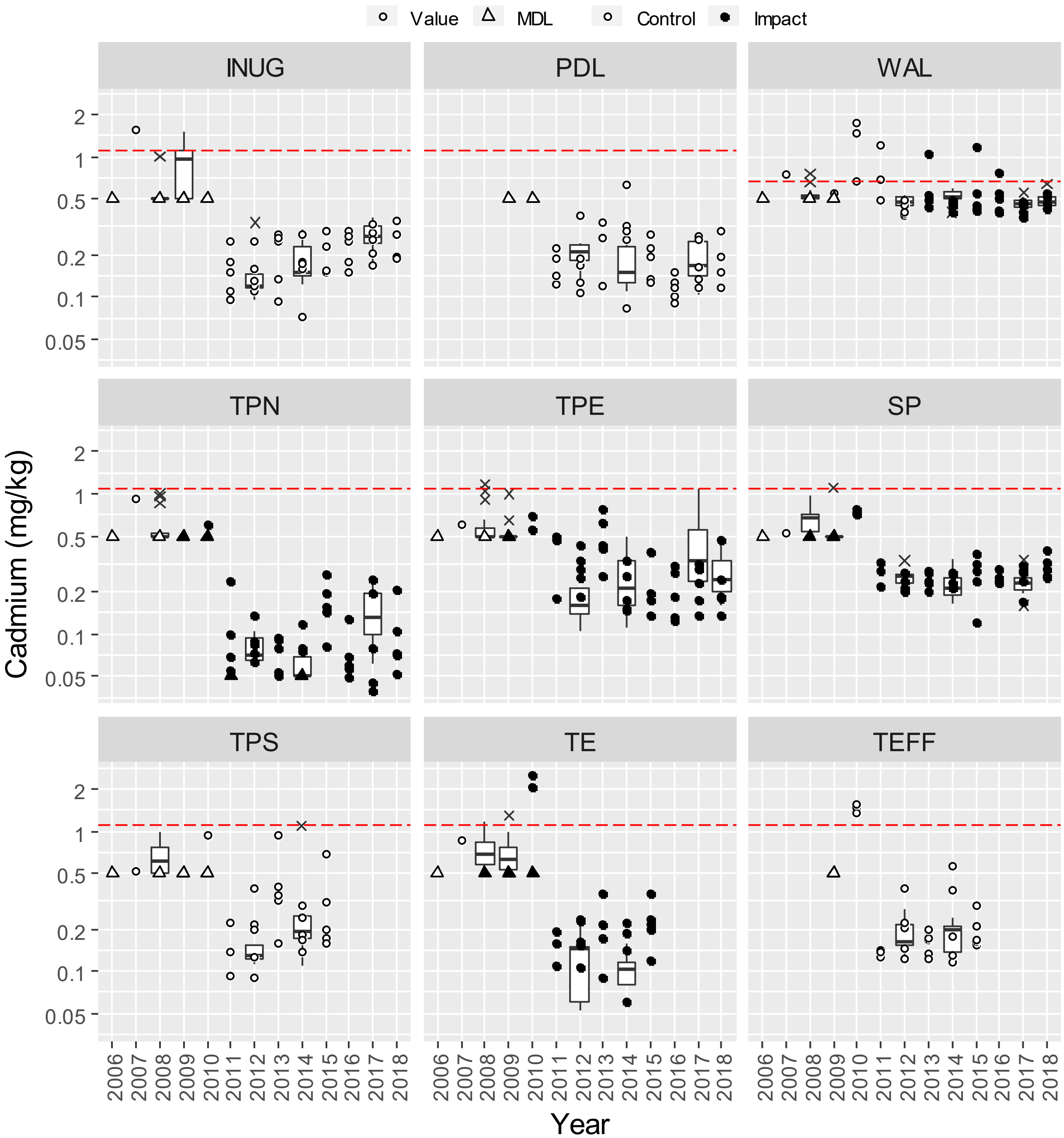


Figure 4-63. Total chromium (mg/kg) in sediment samples (grabs & cores) from Meadowbank project lakes since 2006.

Note: Grab samples = dots; Core samples = box and whisker
The red dash line represents trigger values

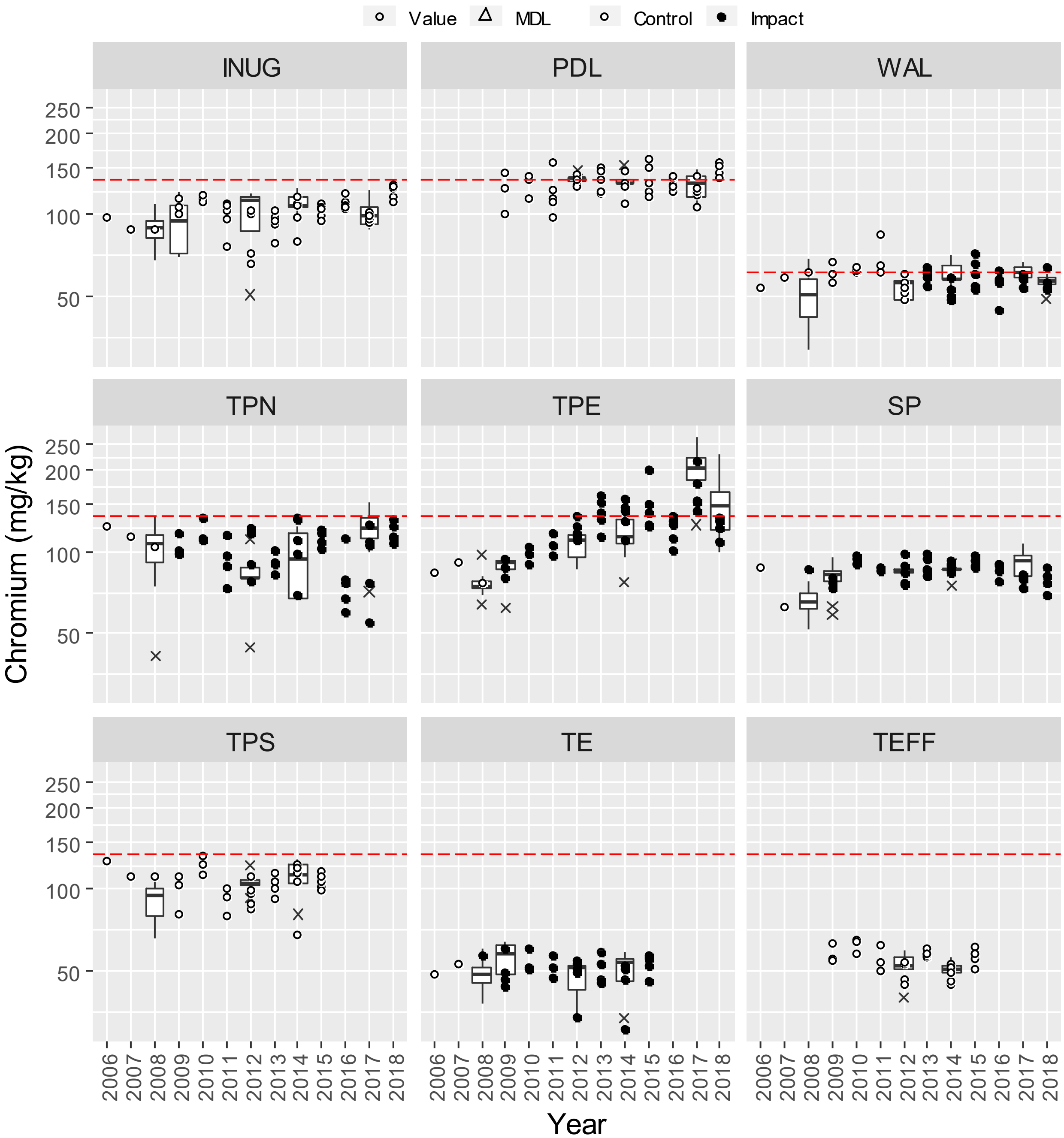


Figure 4-64. Total copper (mg/kg) in sediment samples (grabs & cores) from Meadowbank project lakes since 2006.

Note: Grab samples = dots; Core samples = box and whisker
The red dash line represents trigger values

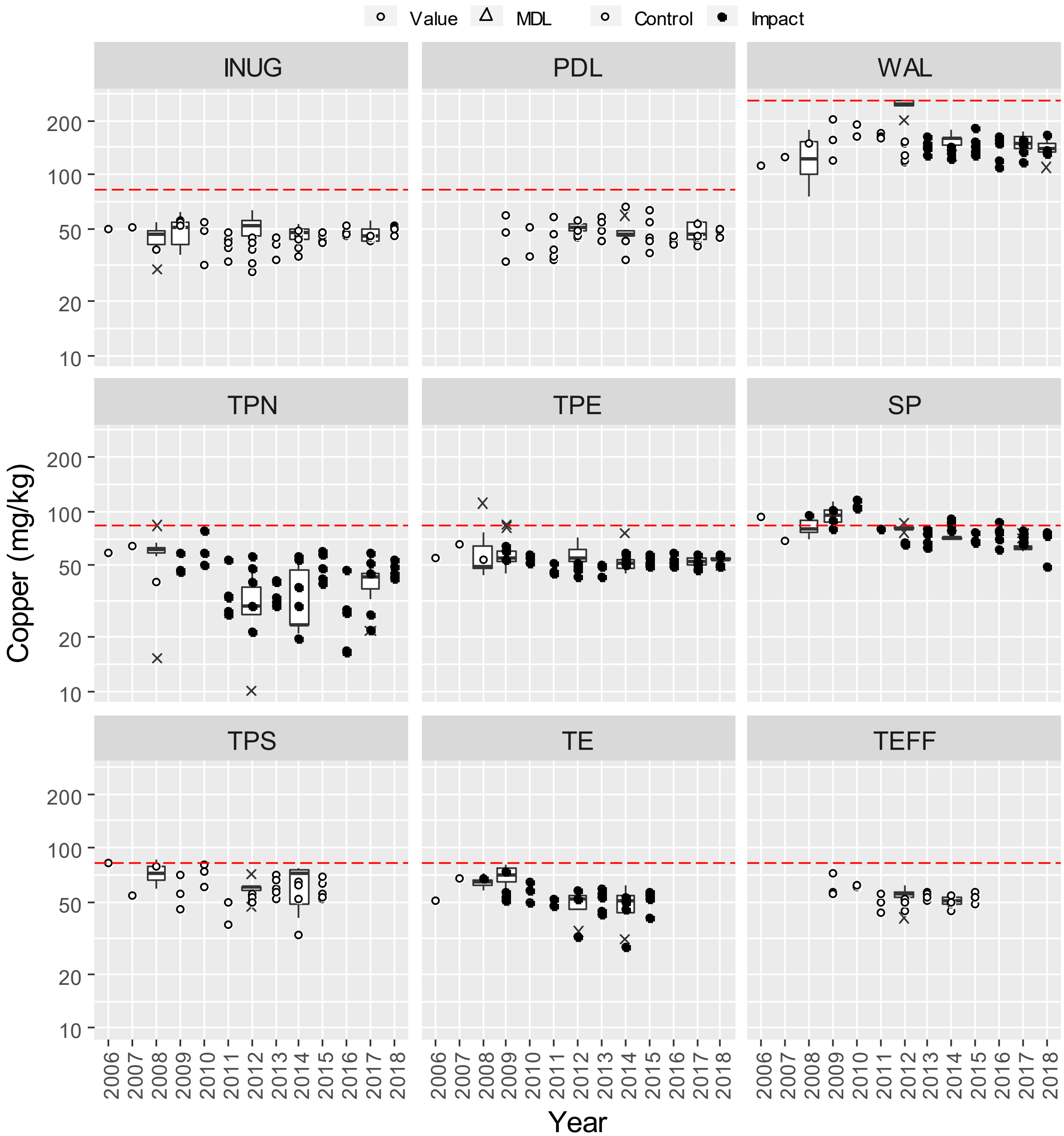


Figure 4-65. Total lead (mg/kg) in sediment samples (grabs & cores) from Meadowbank project lakes since 2006.

Note: Grab samples = dots; Core samples = box and whisker
The red dash line represents trigger values

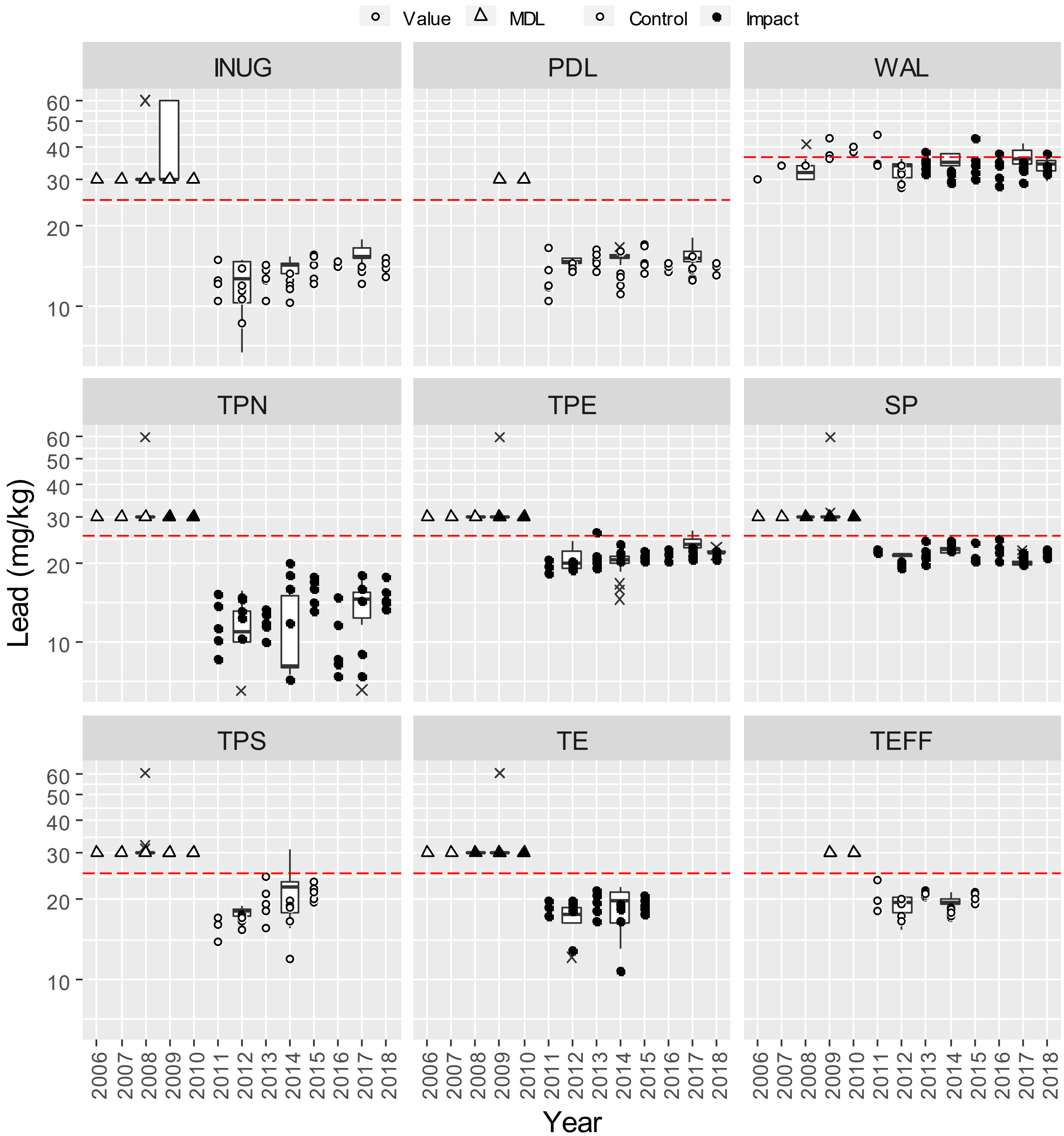


Figure 4-66. Total mercury (mg/kg) in sediment samples (grabs & cores) from Meadowbank project lakes since 2006.

Note: Grab samples = dots; Core samples = box and whisker
The red dash line represents trigger values

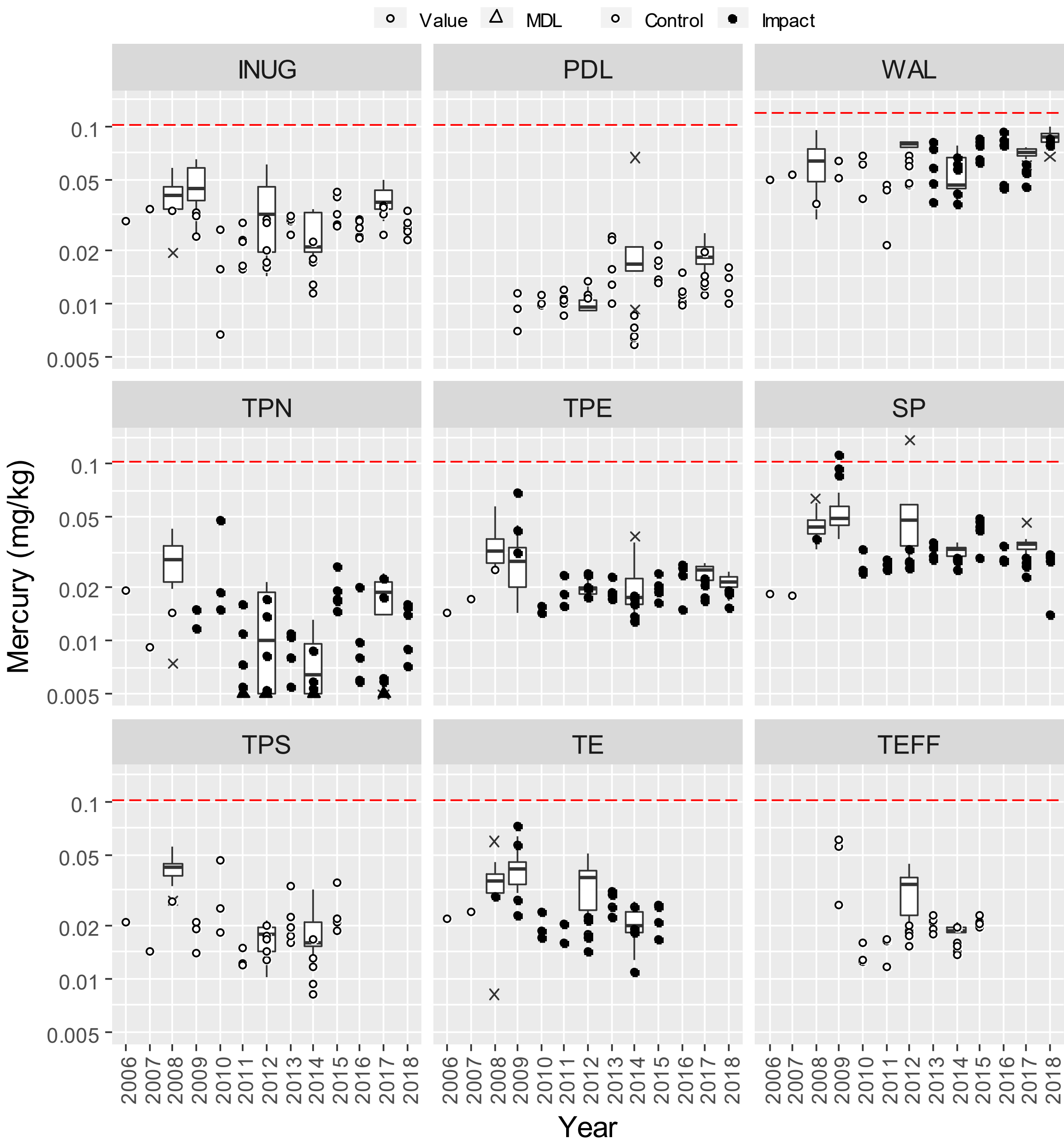
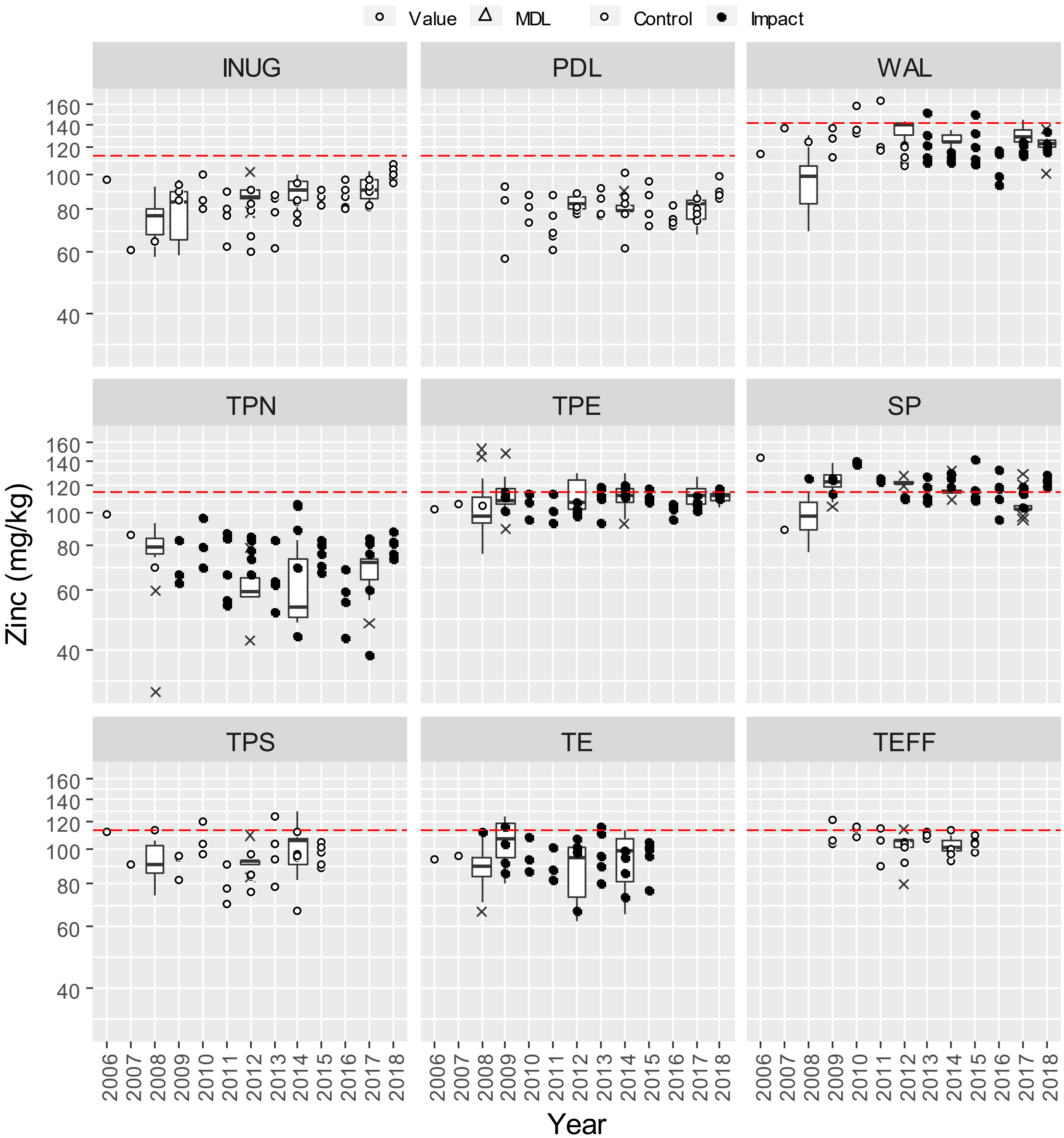


Figure 4-67. Total zinc (mg/kg) in sediment samples (grabs & cores) from Meadowbank project lakes since 2006.

Note: Grab samples = dots; Core samples = box and whisker
The red dash line represents trigger values



Benthos Community Tables and Figures

Table 4-9. Geometric means for total abundance and total richness, Meadowbank study lakes.

Geometric means for Total abundance[1]													
Station	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
INUG	731 (11)	975 (9)	1300 (6)	1129 (7)	628 (12)	881 (10)	1042 (8)	1975 (2)	621 (13)	1648 (4)	2100 (1)	1712 (3)	1497 (5)
PDL	NA	NA	NA	1522 (1)	776 (8)	927 (6)	942 (5)	1279 (3)	473 (10)	1127 (4)	1373 (2)	748 (9)	779 (7)
WAL	12894 (2)	4357 (5)	1057 (12)	1834 (8)	1727 (9)	800 (13)	1874 (7)	1445 (11)	2222 (6)	1568 (10)	14253 (1)	4942 (4)	12035 (3)
TPN	NA	1359 (5)	864 (10)	1214 (7)	1029 (9)	498 (11)	1141 (8)	1407 (4)	373 (12)	3025 (1)	1696 (3)	1309 (6)	2051 (2)
TPE	3220 (3)	1563 (12)	5556 (1)	1663 (10)	1126 (13)	1584 (11)	3915 (2)	2244 (9)	2827 (5)	2765 (7)	2787 (6)	3147 (4)	2485 (8)
SP	619 (10)	842 (8)	395 (12)	771 (9)	241 (13)	563 (11)	1169 (7)	2279 (2)	2796 (1)	1927 (4)	1420 (5)	2058 (3)	1298 (6)
TPS	935 (9)	1597 (4)	1501 (6)	1714 (3)	1130 (8)	932 (10)	1932 (2)	1581 (5)	1217 (7)	5939 (1)	NA	NA	NA
TE	913 (4)	930 (3)	743 (8)	757 (6)	517 (10)	725 (9)	747 (7)	819 (5)	1158 (2)	1548 (1)	NA	NA	NA
TEFF	NA	NA	NA	1215 (1)	886 (5)	615 (7)	921 (3)	955 (2)	891 (4)	816 (6)	NA	NA	NA
Geometric means for Total richness													
Station	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
INUG	10.1 (10)	12 (7)	13.5 (4)	13.2 (5)	8.1 (12)	10.5 (9)	10.7 (8)	15.4 (2)	9.3 (11)	12.4 (6)	15.7 (1)	13.6 (3)	14.2 (3)
PDL	NA	NA	NA	11 (1)	9 (6)	9.3 (5)	7.9 (8)	10.3 (2)	5.6 (9)	8.8 (7)	10.1 (3)	9.7 (4)	5.8 (9)
WAL	11.6 (4)	13.1 (2)	7.9 (11)	10.6 (7)	10.4 (9)	6.9 (12)	11.5 (5)	10.5 (8)	10.8 (6)	10.2 (10)	14.5 (1)	13.1 (2)	14.9 (1)
TPN	NA	9.3 (7)	7.5 (10)	9.1 (8)	10.3 (5)	7.8 (9)	10.1 (6)	12.4 (1)	5.7 (11)	10.7 (4)	12.4 (1)	12.2 (3)	12.5 (1)
TPE	8.2 (12)	10.7 (9)	14.2 (1)	11.3 (7)	9.7 (10)	9.3 (11)	12.5 (5)	14 (3)	10.9 (8)	14.1 (2)	13.7 (4)	12.5 (5)	12.9 (5)
SP	6.1 (11)	9.3 (8)	7.1 (10)	7.2 (9)	4.1 (12)	10.2 (7)	12.7 (4)	11.6 (5)	13.3 (2)	12.9 (3)	15.1 (1)	11.2 (6)	10.5 (7)
TPS	10.6 (5)	9.4 (8)	10.7 (3)	10.7 (3)	8.1 (9)	7.8 (10)	10.2 (6)	10.1 (7)	10.8 (2)	16.5 (1)	NA	NA	NA
TE	5 (10)	8.7 (5)	9.9 (2)	7.1 (7)	5.8 (9)	5.9 (8)	8.8 (4)	7.7 (6)	9 (3)	12.8 (1)	NA	NA	NA
TEFF	NA	NA	NA	10.3 (3)	10.6 (2)	8.5 (6)	8.3 (7)	9.5 (5)	10.3 (3)	11.4 (1)	NA	NA	NA

Notes:
1. Total abundance in organisms/m^2.
Rank order of abundance and richness shown in parentheses.
Red vertical lines mark the year that station designations switched from "control" to "impact".
NA = Benthic invertebrate sampling was not completed for the given station/year.

Table 4-10. Results of the BACI tests for benthic invertebrate abundance at Meadowbank study lakes.

After Period	Test Area	n(B)	n(A)	Estimate	SE	P-value*	Effect size (%)		
							ES	LCI	UCI
2018	TPN	2	1	0.35	0.47	0.71	42	-100	52,556
	TPE	3	1	-0.61	0.67	0.23	-46	-97	856
	SP	2	1	0.01	0.26	0.51	1.1	-96	2,541
	WAL	7	1	1.24	0.99	0.87	245	-69	3,739
2017-18	TPN	2	2	0.06	0.36	0.56	6.4	-77	393
	TPE	3	2	-0.56	0.43	0.14	-43	-85	126
	SP	2	2	0.18	0.21	0.75	19	-52	197
	WAL	7	2	0.73	0.71	0.83	107	-62	1,009
2016-18	TPN	2	3	-0.02	0.30	0.48	-1.7	-62	152
	TPE	3	3	-0.64	0.35	**<u>0.07</u>**	-48	-80	37
	SP	2	3	0.04	0.24	0.56	3.9	-51	119
	WAL	7	3	0.84	0.59	0.91	132	-40	796
2015-18	TPN	2	4	0.15	0.33	0.66	16	-54	189
	TPE	3	4	-0.63	0.29	**<u>0.04</u>**	-47	-75	12
	SP	2	4	0.11	0.22	0.67	11	-40	106
	WAL	7	4	0.40	0.60	0.74	49	-62	485

Notes:

* **<u>Bolded & underline</u>** values are P-values < 0.1

Shaded cells indicate negative effect sizes (reductions) of 20% or more

Test area = area compared to control (INUG)

n(B) = number of years in the "before" period

n(A) = number of years in the "after" period

Estimate = BACI model estimate of the after-period change in mean for log-transformed data

SE = standard error of the estimate

P-value = one-tailed test of the null hypothesis of no change or an increase in mean

ES = estimated effect size (i.e., 100%*(exp[Estimate]-1))

LCI = lower 95% confidence interval; UCI = upper 95% confidence interval

Table 4-11. Results of the BACI tests for benthic invertebrate taxa richness at Meadowbank study lakes.

After Period	Test Area	n(B)	n(A)	Estimate	SE	P-value*	Effect size (%)		
							ES	LCI	UCI
2018	TPN	2	1	0.29	0.23	0.79	34	-93	2,422
	TPE	3	1	-0.02	0.14	0.45	-1.9	-46	78
	SP	2	1	0.06	0.21	0.58	5.8	-92	1,379
	WAL	7	1	0.15	0.31	0.67	16	-46	146
2017-18	TPN	2	2	0.30	0.17	0.89	35	-35	182
	TPE	3	2	-0.02	0.11	0.45	-1.6	-30	38
	SP	2	2	0.10	0.15	0.72	11	-41	108
	WAL	7	2	0.10	0.22	0.68	11	-34	85
2016-18	TPN	2	3	0.26	0.15	0.91	30	-19	106
	TPE	3	3	-0.03	0.09	0.37	-3.1	-25	25
	SP	2	3	0.18	0.14	0.86	19	-23	84
	WAL	7	3	0.07	0.18	0.66	7.7	-28	62
2015-18	TPN	2	4	0.26	0.14	0.94	30	-11	90
	TPE	3	4	0.03	0.09	0.60	2.6	-19	30
	SP	2	4	0.23	0.14	0.91	26	-15	87
	WAL	7	4	0.03	0.16	0.57	3.1	-28	48

Notes:

* **Bolded & underline** values are P-values < 0.1

Shaded cells indicate negative effect sizes (reductions) of 20% or more

Test area = area compared to control (INUG)

n(B) = number of years in the "before" period

n(A) = number of years in the "after" period

Estimate = BACI model estimate of the after-period change in mean for log-transformed data

SE = standard error of the estimate

P-value = one-tailed test of the null hypothesis of no change or an increase in mean

ES = estimated effect size (i.e., 100%*(exp[Estimate]-1))

LCI = lower 95% confidence interval; UCI = upper 95% confidence interval

Figure 4-68. Benthic invertebrate total abundance (#/m^2) from Meadowbank study area lakes since 2006.

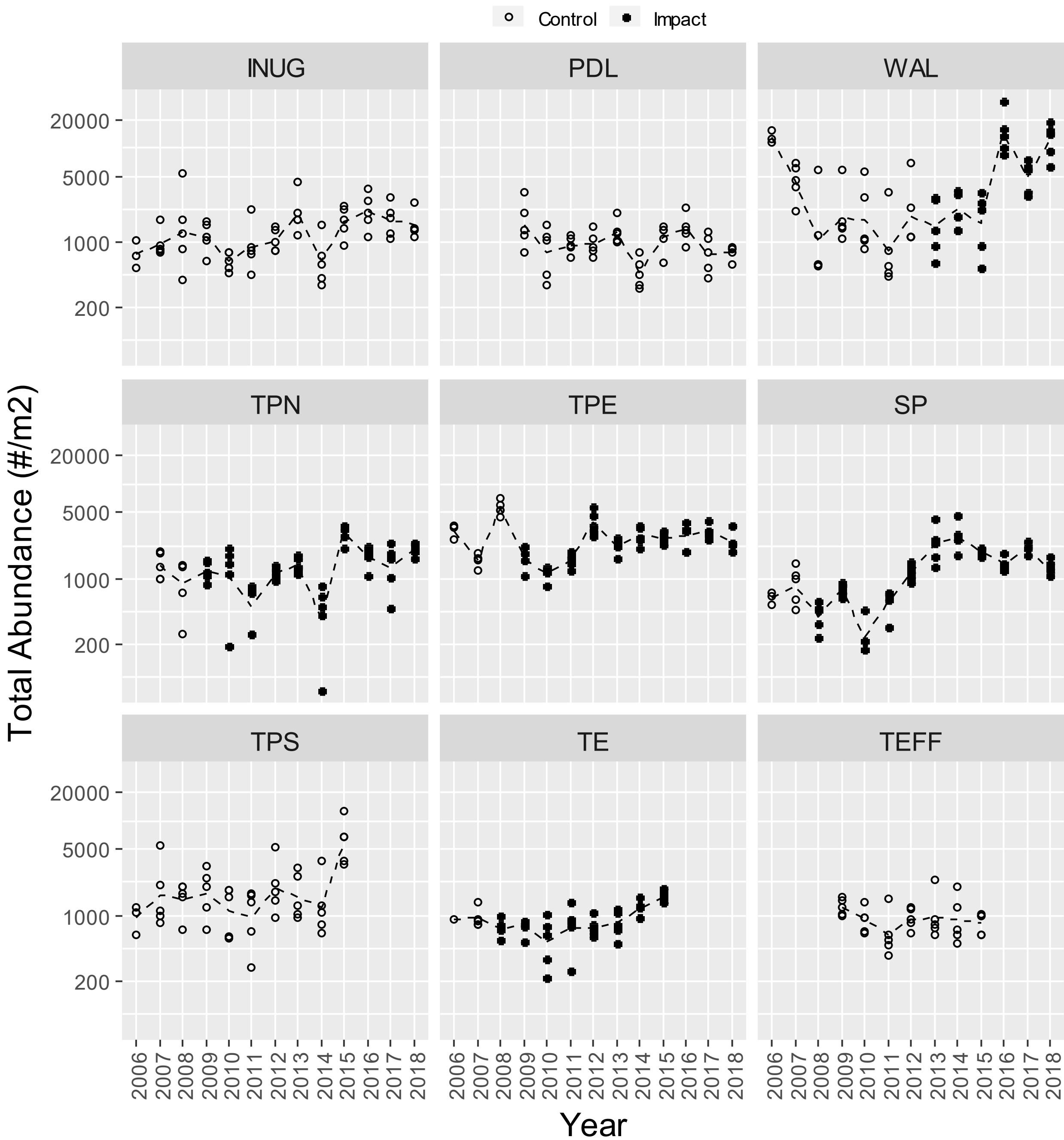


Figure 4-69. Benthic invertebrate abundance (#/m^2) by major taxa group from Meadowbank study area lakes since 2006.

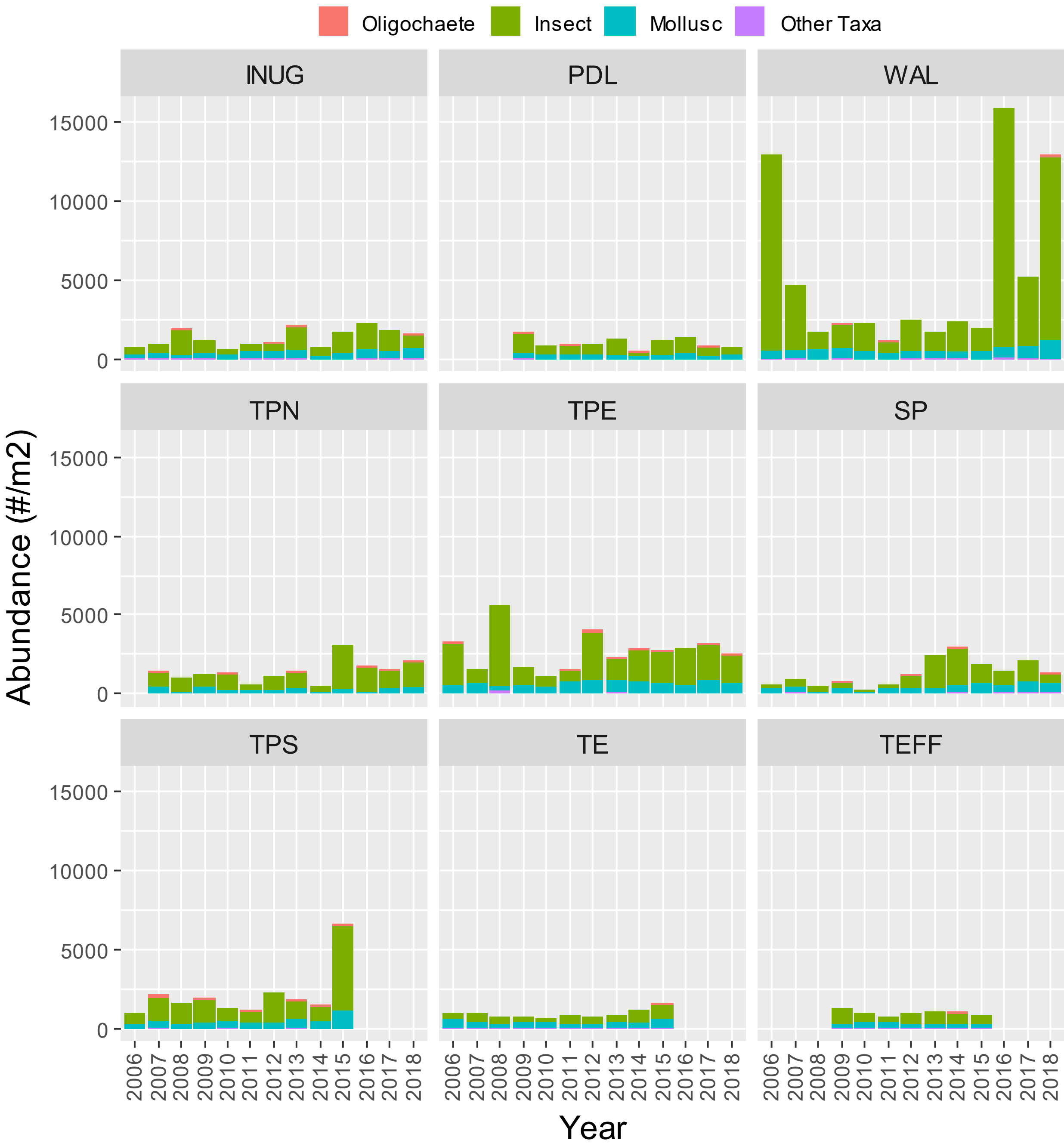


Figure 4-70. Benthic invertebrate relative abundance by major taxa group from Meadowbank study area lakes since 2006.

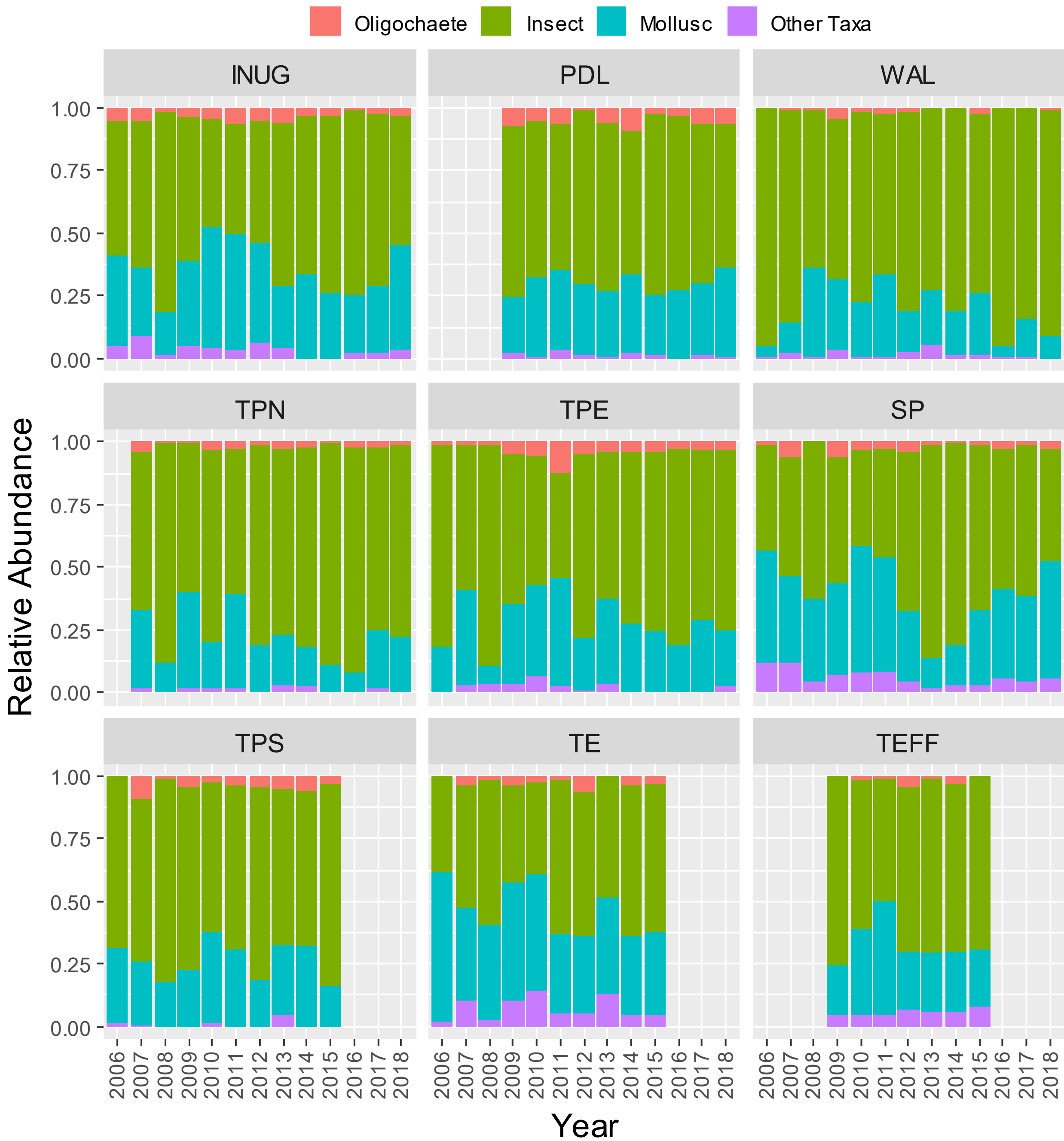


Figure 4-71. Benthic invertebrate total richness (# taxa) from Meadowbank study area lakes since 2006.

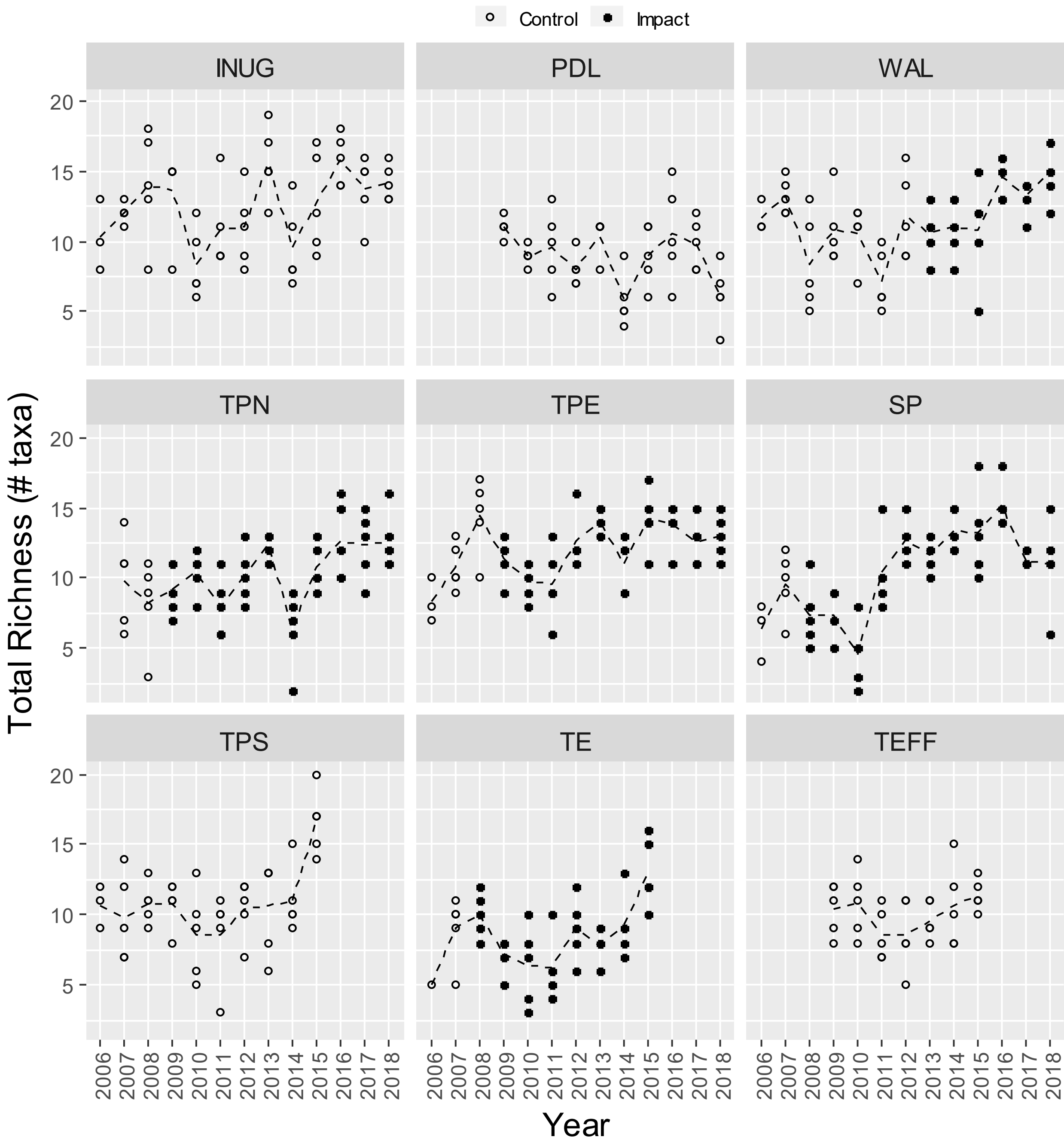


Figure 4-72. Benthic invertebrate richness (# taxa) by major taxa group from Meadowbank study area lakes since 2006.

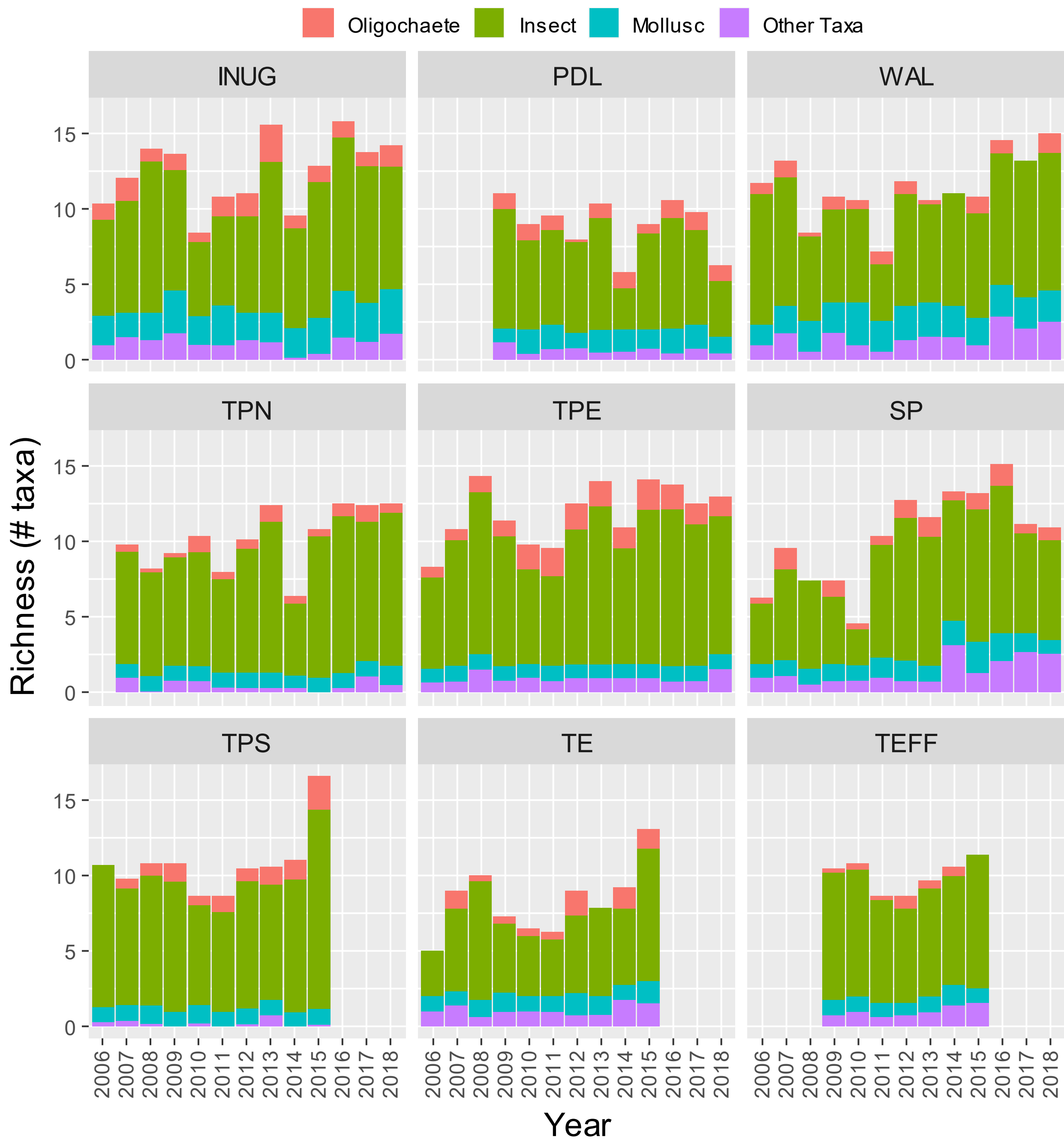
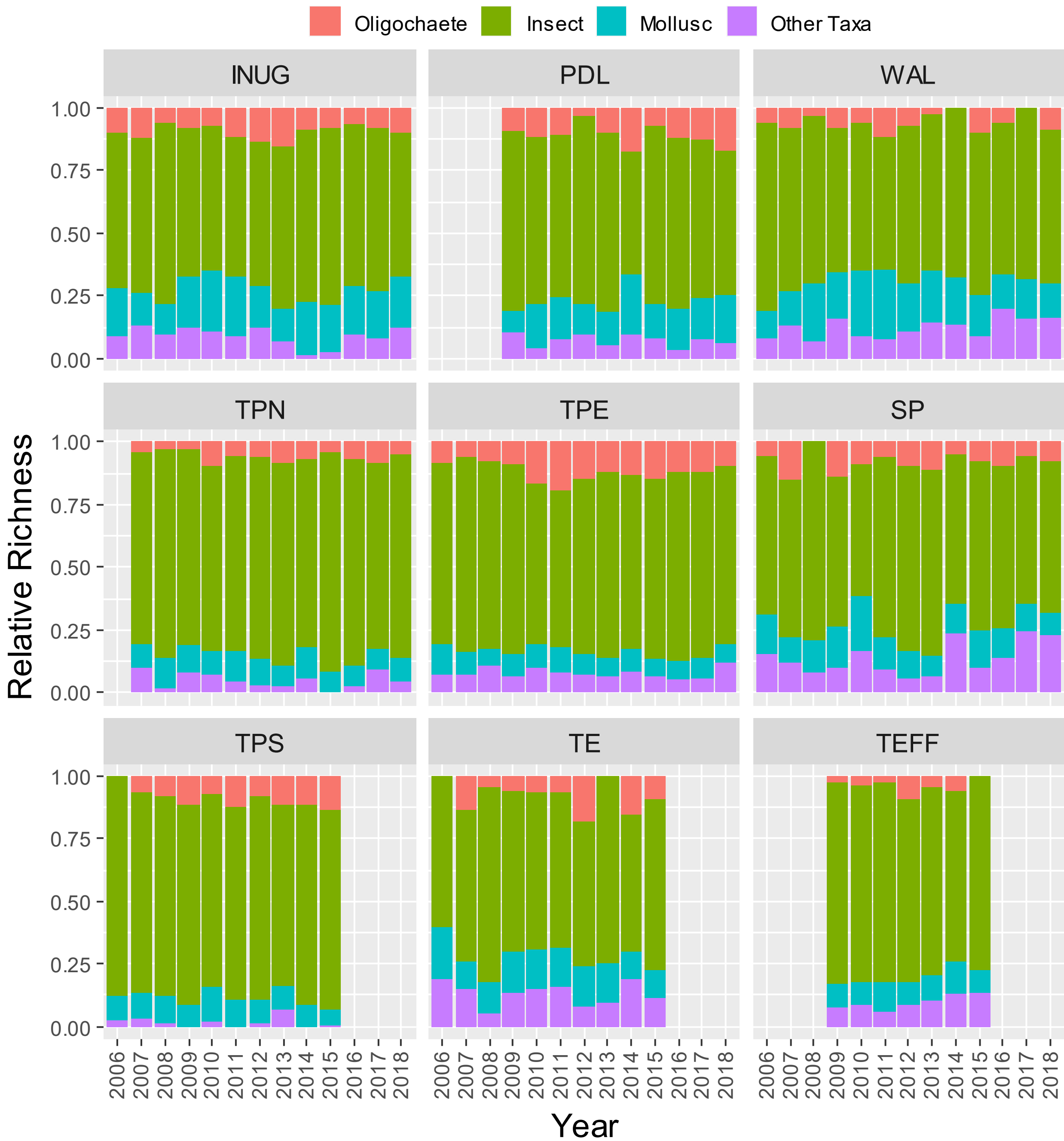


Figure 4-73. Benthic invertebrate relative richness by major taxa group from Meadowbank study lakes since 2006.



Sediment Toxicity Tables and Figures

Table 4-12. *Chironomus dilutus* survival (%) and growth (mg dry weight) results from the sediment toxicity tests at TPE and WAL in 2018.

	C. dilutus Survival (%)					% Survival		
Treatment [1]	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Mean	SD	Effect Size[1]
Control	90	90	100	100	80	92	8.4	-
PDL	90	80	100	100	100	94	8.9	-
INUG	100	100	90	90	90	94	5.5	-
TPE	100	80	100	100	100	96	8.9	2%
WAL	90	100	90	60	80	84	15.2	-11%

	Mean wt./organism (mg)					wt./Sample		
Treatment [1]	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Mean	SD	Effect Size[3]
Control	1.86	2.16	1.64	1.58	2.10	1.87	0.26	-
PDL	2.49	2.44	2.19	2.29	2.19	2.32	0.14	-
INUG	2.26	2.29	2.36	2.48	2.34	2.35	0.09	-
TPE [b,c]	1.85	1.76	1.78	1.90	2.00	1.86	0.10	-20%
WAL	2.14	2.61	2.05	2.48	2.65	2.39	0.28	2%

Notes:

1. Statistically significant differences from the control treatments: laboratory (a), INUG (b), and PDL (c)
2. Mean effect size ratings calculated relative to the mean of the pooled reference data for INUG and PDL

Negligible	<10% reduction in mean survival or growth
Low	10-20% reduction in mean survival or growth
Moderate	20-50 % reduction in mean survival or growth
High	> 50 % reduction in mean survival or growth

Table 4-13. *Hyalella azteca* survival (%) and growth (mg dry weight) results from the sediment toxicity tests at TPE and WAL in 2018.

Treatment [1]	*H. azteca* Survival (%) Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	% Survival Mean	SD	Effect Size[2]
Control	90	100	90	100	100	96	5	-
PDL	90	100	100	100	100	98	0	-
INUG	70	100	90	100	100	92	5	-
TPE[a,b,c]	0	0	0	40	100	28	47	-71%
WAL	90	100	100	100	100	98	0	3%

Treatment [1]	Mean wt./*organism* (mg) Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	wt./Sample Mean	SD	Effect Size[2]
Control	0.12	0.24	0.20	0.22	0.21	0.20	0.05	-
PDL	0.22	0.20	0.20	0.22	0.14	0.20	0.03	-
INUG	0.19	0.18	0.20	0.19	0.20	0.19	0.01	-
[3] TPE[a,b,c]	-	-	-	0.10	0.14	0.12	0.03	-38%
[4] TPE[a,b,c]	0	0	0	0.10	0.14	0.05	0.07	-75%
WAL	0.25	0.18	0.19	0.22	0.20	0.21	0.03	8%

Notes:

1. Statistically significant differences from the control treatments: laboratory (a), INUG (b), and PDL (c)
2. Mean effect size ratings calculated relative to the mean of the pooled reference data for INUG and PDL

Negligible	<10% reduction in mean survival or growth
Low	10-20% reduction in mean survival or growth
Moderate	20-50 % reduction in mean survival or growth
High	> 50 % reduction in mean survival or growth

2. Mean dry weight calculated excluding reps with zero survival.
3. Mean dry weight calculated including reps with zero survival.

Figure 4-74. Growth and survival results for the *Chironomus dilutus* sediment toxicity tests.

Note: Statistical comparisons shown for the 2018 test results. Different letters indicate there is a statistically significant difference compared to the lab control ("a"), INUG ("b"), or PDL ("c").

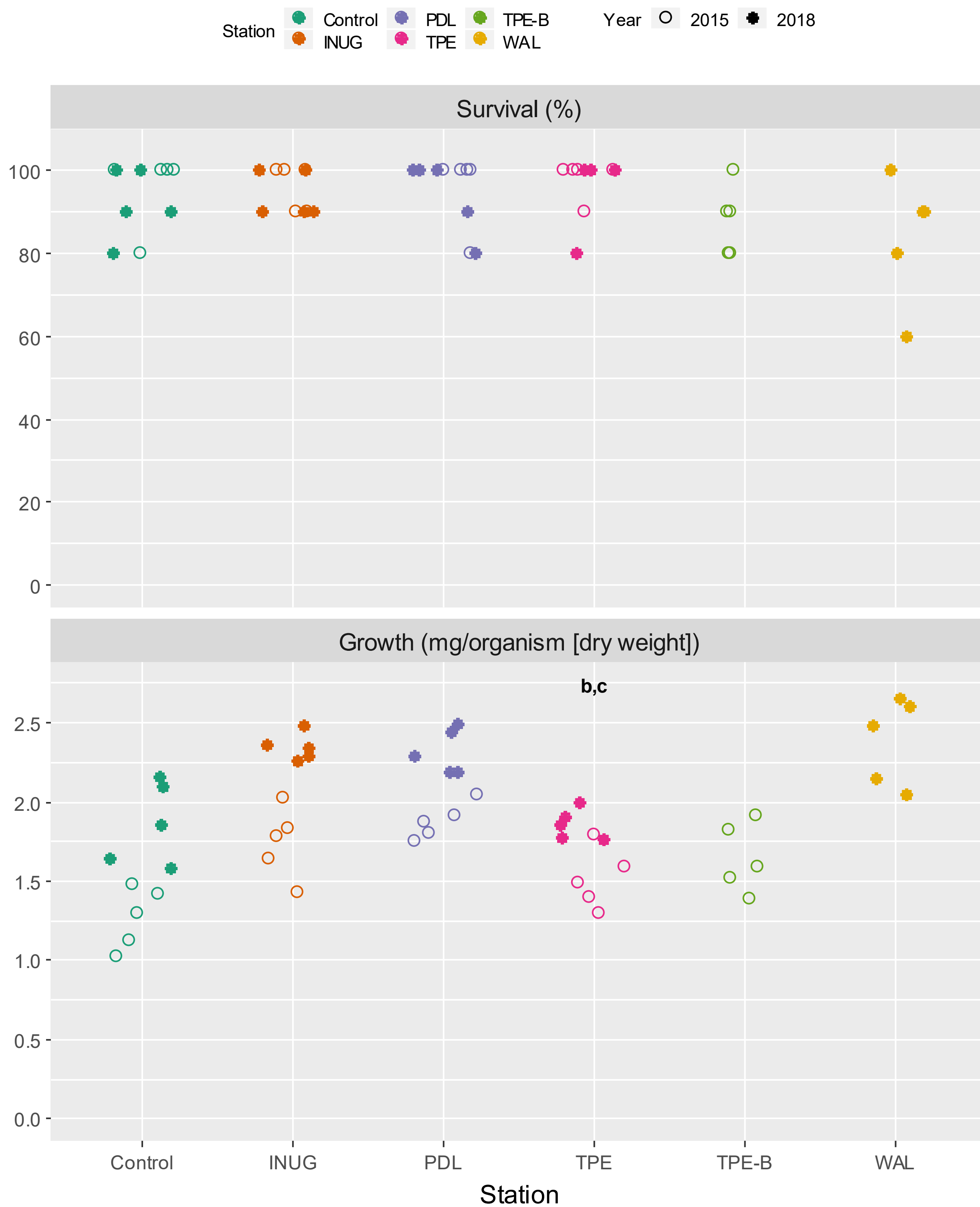


Figure 4-75. Growth and survival results for the *Hyalella azteca* sediment toxicity test.

Note: Statistical comparisons shown for the 2018 test results. Different letters indicate there is a statistically significant difference compared to the lab control ("a"), INUG ("b"), or PDL ("c").

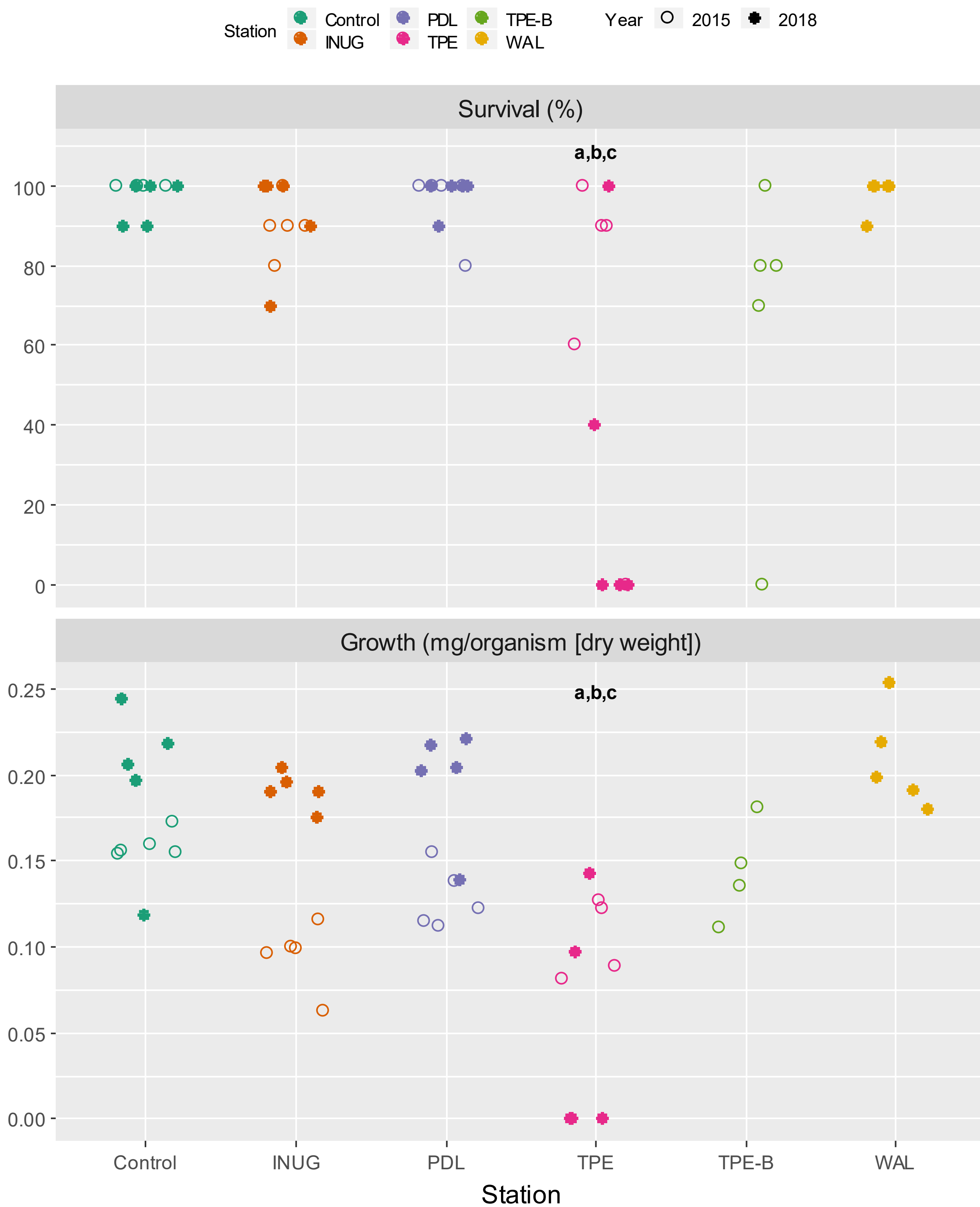
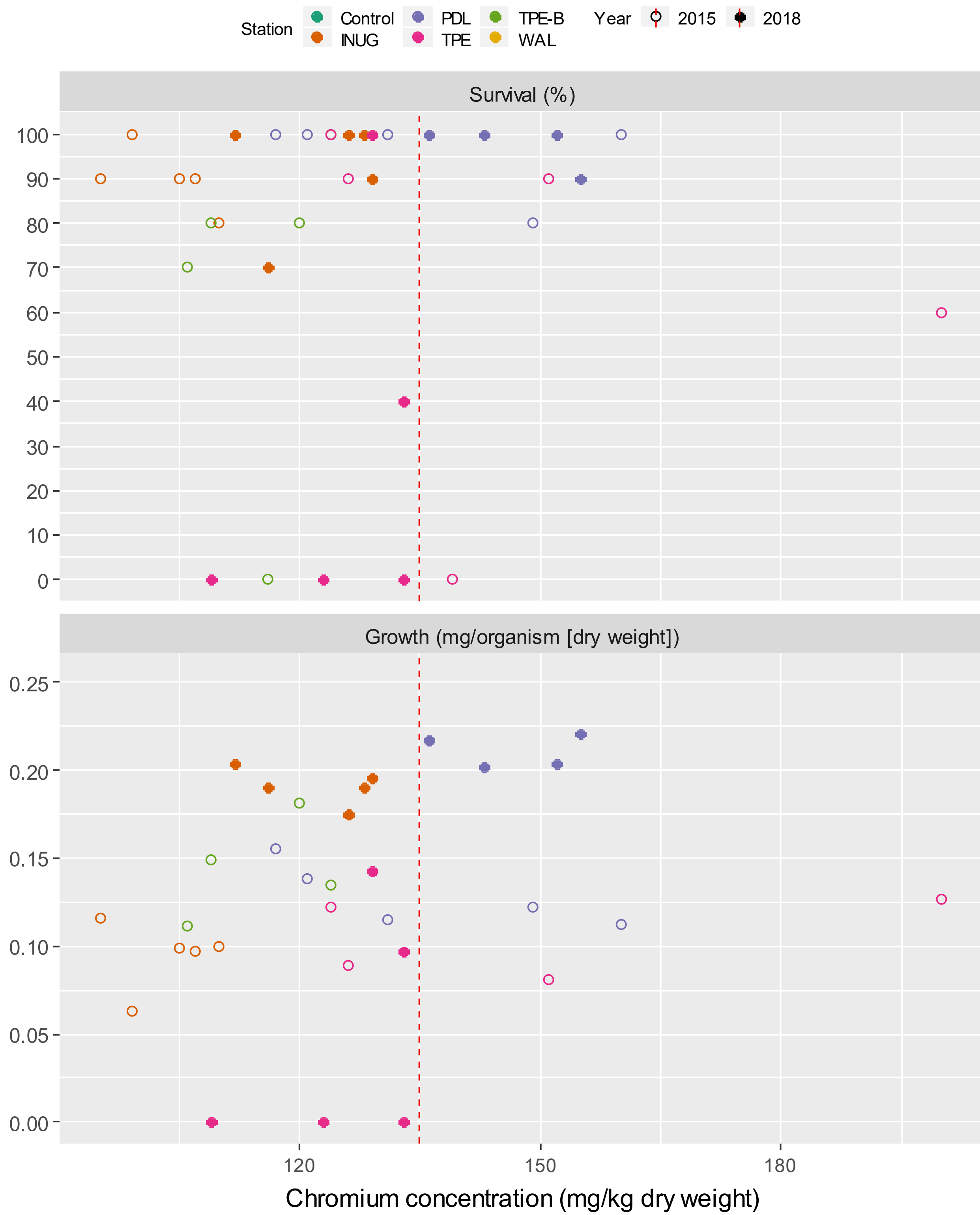


Figure 4-76. Growth and survival relative to sediment chromium concentrations for the *Hyalella azteca* sediment toxicity test.

Note: The red line represents the trigger value for chromium (135 mg/kg; CCME sediment quality guidelines are ISQG = 37.3 mg/kg; PEL = 90 mg/kg).



5. WHALE TAIL

5.1. Overview of the 2018 Whale Tail CREMP

This section of the CREMP report summarizes the water quality monitoring results, sediment chemistry, phytoplankton, community, and benthic invertebrate communities in support of the Whale Tail Project in 2018. Figures and tables relevant to the Whale Tail Project are organized at the end of the section.

The six lakes currently[21] included in the study design for monitoring mining-related changes downstream of the Whale Tail Project are:

- Near-field: Whale Tail Lake – South Basin (WTS), Mammoth Lake (MAM), and Nemo Lake (NEM)
- Mid-field: Lake A20 and Lake A76
- Far-field: Lake DS1

Existing Meadowbank reference areas INUG and PDL serve as reference areas for the Whale Tail study area lakes. Water quality sampling locations are shown in **Figure 5-1**. Sediment and benthic invertebrate sampling areas are shown in **Figure 5-2.**

2018 was a transition year for the Whale Tail Project. Area designations changed from *control* to *impact* for WTS and MAM in 2018 as a result of the onset of construction activities and the *potential* for changes in water and sediment quality in each lake to result in changes in the biological communities. The other four lakes were unaffected by construction activities in 2018 and remained in the baseline ("control") designation for 2018. WTS switched to *impact* for the August sampling event with the onset of dike construction in Whale Tail Lake on July 28th. Construction activities in the vicinity of Mammoth Lake were limited during the open water season. Road construction (Road 9; **Figure 5-3**) from the west side of Whale Tail Lake to a temporary crusher pad north of Mammoth Lake was started on August 9th. The timing of construction meant open water season construction impacts to water quality were considered unlikely. Crushing activities started on October 21st after Mammoth Lake had frozen over. Dust suppression controls were used during the crushing process to reduce dust. Based on the location and timing of construction activities, the area designation for MAM was changed from *control* to *impact* for the November sampling event.

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[21] Additional lakes may be added to the study design to fulfill monitoring requirements in the approved scope of the Project.

5.2. Limnology

Limnology data provides an initial assessment of whether conditions are changing within a sampling area that may require additional follow-up investigation. The general timing of the limnology and water sampling program coincided with the Meadowbank CREMP sampling program. Two limnology profiles for temperature, dissolved oxygen, and conductivity were collected synoptically with water chemistry and phytoplankton sampling in May, July, August, September, and November. One depth profile was conducted monthly from WTS, MAM, and NEM in December to monitor for potential changes in NF water quality.

Tabulated limnology data collected are included in **Appendix H**. May, July, September, November and December measurements were taken by Agnico Eagle Environment Department personnel. Azimuth completed the August sampling event. Locations where limnology profiles were conducted are shown in **Figure 5-1**. Each point shown on the map is labelled with a number corresponding to the month the profiles were collected (e.g., 5 = May). Presentation of results for each lake focus on the deepest location sampled per event; matching synoptic water chemistry sample IDs (where available) for 2018 are listed in **Table 5-1** for cross-reference.

Table 5-1. Samples included in the 2018 limnology profiles for the Whale Tail study area lakes.

Area	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
WTS	WTS-27	Not sampled	WTS-30	WTS-31	WTS-33	Not sampled	WTS-36	☑
MAM	MAM-28		MAM-30	MAM-32	MAM-34		MAM-35	☑
NEM	NEM-28		NEM-30	NEM-31	NEM-34		NEM-35	☑
A20	A20-21		A20-23	A20-25	A20-28		A20-30	
A76	A76-22		A76-24	A76-26	A76-27		A76-30	
DS1	DS1-19		DS1-21	DS1-23	DS1-26		DS1-27	

Notes:

☑ = One profile is collected from the near-field areas in months where water sampling is not completed.

The samples shown represent the deepest of the two locations sampled each month.

5.2.1. General Observations

The lakes in the Whale Tail study area are, for the most part, shallow and oligotrophic. DS1 is the deepest lake in the study area, with a maximum recorded depth of approximately 33 m. A20, A76, and NEM have areas of steep relief, but the majority of the surface area is less than 15 m deep.

Similar to the Meadowbank lakes, the ice-free season is short for lakes within the Whale Tail study area. Ice break-up usually occurs during mid- to late-June in the region and begins to form again on the lakes beginning in October. Sampling in June and October is generally avoided due to safety concerns surrounding ice conditions. Surface water temperatures measured at 3 m typically reach a yearly high of between 10°C and 15°C sometime in August (**Figure 5-4**) before cooling in the fall.

5.2.2. Temporal and Spatial Trends

Temperature, specific conductivity, and, dissolved oxygen profiles for May, July, August, September, and December are shown in **Figure 5-5**. Profiles for INUG and PDL are included in each monthly plot for reference.

Temperature and Dissolved Oxygen

The temperature and dissolved oxygen profile results are discussed together because they produce similar outcomes when interpreting spatial and temporal trends in water quality. Strong winds, combined with the shallow depths, help maintain uniform temperature and high oxygen profiles in the water column during the open-water season. This also ensures that the distribution of phytoplankton and to a lesser extent, zooplankton is vertically more uniform. Thermal stratification, if any, is brief in these lakes (days) and water temperatures only differ 4°C to 5°C between surface and bottom during these times when the wind is calm.

The lakes are well oxygenated throughout the year, with DO generally above 10 mg/L (**Figure 5-5**). Vertical stratification in DO was evident at most sampling areas in the May 2018 event. The extent of vertical stratification was most apparent at Mammoth Lake, where concentrations decreased from over 15 mg/L below the ice to approximately 7.5 mg/L near at 15 m near the bottom of the lake. A similar pattern was observed at INUG in May, demonstrating the natural variability in winter DO concentrations for lakes in the region.

Conductivity

Whale Tail Lake – South Basin – Specific conductivity is an effective and sensitive measure of changes in water quality due to construction activities, as increases in total dissolved solids result in increased electrical conductance. The onset of dike construction in Whale Tail Lake did not result in changes in specific conductivity at WTS. Profiles taken at WTS in July and August were virtually identical, measuring 35 µS/cm and 38 µS/cm in August and September (**Figure 5-5**). Through-ice monitoring in November and December showed conductivity remained low after ice formed on the lake. These results demonstrate the effectiveness of the turbidity control measures at maintaining good water quality during the open water construction season in WTS.

Mammoth Lake – There was some evidence of seasonal changes in water quality at MAM based on the late-season conductivity profile data collected in November and December compared to the other sampling events. Data collected in May, July, August, and September showed very little seasonality, no evidence stratification, and were consistent with baseline measurements (generally less than 75 µS/cm). By comparison, the November and December profiles taken near the northeast corner of Mammoth Lake (**Figure 5-1**) showed a clear pattern of vertical stratification with concentrations increasing from towards the lake sediment (**Figure 5-5**). In November, conductivity increased from approximately 100 µS/cm just below the ice to 150 µS/cm near the bottom (~8 m). The profile readings taken from the same area of Mammoth Lake in December confirmed the trend of increasing conductivity with top to bottom surface readings increasing from 135 µS/cm to 175 µS/cm near the bottom (~5 m). The second profile collected in November from the southwest corner of Mammoth Lake had lower conductivity (70 µS/cm and 80 µS/cm) and no evidence of vertical stratification. These reported conductivity readings are at the upper end of the range reported during the baseline period (2014 to 2017). Combined, the November *in-situ* conductivity data suggest surface water is not well mixed horizontally and vertically throughout the lake, which makes sense given the lack of wind-driven mixing under an ice cover.

The timing of the observed change in conductivity coincides with late-season road construction and crushing activities northeast of Mammoth Lake. The source of increased conductivity to Mammoth Lake is unknown, but given ice was on the lake in November, dust from crushing activities seems unlikely.

Downstream Areas – Conductivity readings indicated very little seasonal variability at NEM and the exposure lakes downstream of MAM and WTS in 2018. Vertical profiles were generally similar top to bottom in each sampling months, suggesting the lakes were well mixed during the open water season. Through-ice sampling showed some evidence of cryo-concentration at A76 in November and NEM in December (**Figure 5-5**), but the measurements were well within the normal range of between 15 µS/cm to 60 µS/cm reported during the baseline period (Azimuth, 2018b). Minor seasonal fluctuations in conductivity are normal between years and seasons, but overall there is no indication of downstream changes in water quality as a result of the onset of construction activities in 2018.

5.3. Water Chemistry

Baseline water quality data collected between 2014 and 2017 in the Whale Tail study area lakes were summarized in the comprehensive baseline CREMP report (Azimuth, 2018b). Formal statistical analysis of changes in water quality (i.e., BACI analyses) were not undertaken in 2018 because of the limited amount of “after” data for WTS (changed to “after” in August) and MAM (changed "after" in November) in 2018 and the expectation that construction-related changes in water quality would be easy to detect visually. Water quality triggers and thresholds specific to the Whale Tail study area will be developed and applied in formal analysis of the 2019 water quality data. In lieu of formal triggers for the Whale Tail study area lakes, the Meadowbank triggers are shown in the figures this year to help put the water quality data in context with information from other lakes in the region.

Tabulated water quality data for 2018, screened against the federal water quality guidelines and the Meadowbank triggers, are tabulated in **Table B2-1**. Temporal trends were evaluated using chemistry plots for conventional parameters (e.g., conductivity, hardness, alkalinity, etc.), nutrients (e.g., nitrate, nitrite, sulphate, etc.) and a subset of metals (total and dissolved) that were detected with some frequency in 2018[22]:

- Conventional water quality parameters are shown in **Figure 5-6** to **Figure 5-12**.
- Key nutrients and organic carbon concentrations are presented in **Figure 5-13** to **Figure 5-21**.
- Metals (total and dissolved) are shown in **Figure 5-22** to **Figure 5-37**.

5.3.1. General Observations

Similar to the Meadowbank lakes, interpretation of water quality results warrants consideration of some general characteristics these lakes share:

- The study lakes are generally nutrient-poor, thermally un-stratified and well-mixed (uniform temperature and oxygen profiles), with no winter anoxia beneath an ice cover.
- The study lakes are headwater lakes, so there are no significant natural sources of nutrients or sediment introduced to these lakes, save only local runoff that contributes little nutrient enrichment, but sustains these aquatic ecosystems. Many chemical parameters in water have been typically below laboratory detection limits (MDLs) since baseline monitoring started in 2014.

Water quality in the Whale Tail study area lakes is characteristic of northern headwater lakes. Surface water hardness is soft, typically measuring less than 20 mg/L (as $CaCO_3$) at during the baseline period (**Figure 5-7**). The buffering capacity of the surface water is also quite low as evidenced by alkalinity concentrations (as bicarbonate) typically below 6 mg/L (**Figure 5-12**). Based on total phosphorus, the lakes are ultra-oligotrophic (< 0.004 mg/L; CCME, 2004);

[22] Plots for parameters that were infrequently measured or otherwise not discussed in the main report are included in **Appendix B2**. Application of a more formal parameter screening process similar to that used for Meadowbank will be implemented in next year's report.

productivity is discussed in more detail in **Section 5.4**. Productivity of northern lakes can be limited by low concentration of nitrogen, phosphorus or both (Ogbego et al., 2009); concentrations of nitrate, nitrite, and phosphorus were frequently below their respective detection limits during the baseline period (**Figure 5-15**, **Figure 5-16**, **Figure 5-18**). Despite being situated in a region of mineralized geology, concentrations of metals are generally low or below MDLs; when measurable, most metals are associated with the particulate phase (i.e., total rather than dissolved).

5.3.2. Temporal and Spatial Trends

Baseline monitoring for this project started in 2014. As described in **Section 5.1**, 2018 was a transition year with in-water construction activities starting in Whale Tail Lake in August. Thus, while most sampling areas are still in the "before" period, WTS and MAM changed status to the "after" period in August and November, respectively. Given the limited amount of data in the "after" period and the absence of site-specific triggers and thresholds, the discussion below for this year starts with a comparison to CCME water quality guidelines then focuses on changes in water quality observed after the onset of construction activities. Lastly, comparisons were made to FEIS predictions. Future assessments will follow the same process used for Meadowbank (**Section 4.3.2**) and Baker Lake (**Section 6.3.2**).

Comparison to CCME Water Quality Guidelines

The potential for effects to biota from changes in water quality were assessed by comparing the 2018 chemistry data against the CCME water quality guidelines WQGs (**Appendix B2**). Reported results from 2018 shown good water quality at all six lakes in 2018 in spite of major in-water construction activities in Whale Tail Lake. The turbidity curtain was effective at minimizing sediment loading to WTS as evidenced by TSS concentrations that, while measurable in both August samples and in one of two September samples, were below the TSS trigger value of 3 mg/L for Meadowbank (**Figure 5-10**). The only parameters with detected values that exceeded the CCME WQGs were the lower pH range (6.5) and total phosphorus (0.004 mg/L) (**Appendix B2**). While accurate pH readings can be particularly challenging in field environments, field-measured readings, despite their higher variability relative to laboratory-measured readings, are generally considered to better represent conditions at the time of sampling. September and November field pH results for most areas were low and none of the excursions below pH 6.5 coincided with "impact" areas, indicating that the results were due to natural variability. The guideline for phosphorus is not associated with adverse effects *per se*, but are operationally-defined break points separating categories of system trophic status (CCME, 2004). The Whale Tail study area lakes are considered ultra-oligotrophic with concentrations of total phosphorous typically below 0.004 mg/L. Occasional exceedances of the ultra-oligotrophic CCME trigger value were observed in the baseline dataset, and the measured concentrations in 2018 are within the range of baseline concentrations in the various lakes and occurred prior to the onset of construction activities (**Figure 5-18**).

Water Quality Patterns Related to Construction Activities

As a complement to the comparison to CCME WQGs, this section looks at all apparent changes in water quality that occurred in conjunction with construction activities for the Whale Tail Project. WTS and MAM are discussed first, followed by a brief description of the other near-field area (NEM), and mid-field (A20 and A76) and far-field areas (DS1), which did not change status in 2018 (**Table 2-4**).

Whale Tail Lake – South Basin (WTS) – Dike construction resulted in predictably higher concentrations of some parameters at WTS in the last half of 2018. The highest-reported TSS concentration at WTS in 2018 was approximately 2 mg/L in the August sampling event. By September, TSS concentrations were near or below the detection limit of 1 mg/L. Parameters that were elevated due to higher TSS in August were total (unfiltered) aluminum (**Figure 5-22**) iron (**Figure 5-26**), chromium (**Figure 5-25**) and to a lesser magnitude arsenic (**Figure 5-23**), copper (**Figure 5-24**), and lead (**Figure 5-27**). The duration of exposure was brief and by September concentrations were trending lower. The November sampling event confirmed that water quality in WTS was representative of baseline conditions.

Mammoth Lake (MAM) – TSS was below detection in all 5 sampling events in 2018, but several parameters exhibited increases in 2018 that coincide with increased construction activity on site. Concentrations of total dissolved solids (TDS), hardness (and major cations), conductivity, nitrate, nitrite, chloride were elevated at MAM in later half of 2018 relative to the baseline period, with concentrations in November among the highest reported for the lake. Surface water flows from north end of Whale Tail Lake (WTN) to Mammoth Lake (Golder, 2016), and its plausible that changes in water quality in WTN resulted in elevated concentrations of some parameters in Mammoth Lake, particularly at the east end of the lake. MAM-35 was collected closest to ephemeral stream connecting Mammoth Lake to WTN, and the parameters shown in the figures below were consistently higher at this location compared with MAM-36 which was sampled at the southwest end of the lake. Nitrate, for example, was 0.11 mg/L at MAM-35 compared to < 0.005 mg/L at the other end of the lake. Elevated concentrations of nitrate, among other forms of nitrogen, are characteristic of blasting activities during mining construction (BC MOE, 2016). Metals such as aluminum, chromium, lead, and zinc were also elevated in November at MAM-35 relative to MAM-36. Development of Quarry 1 and 2 around the periphery of WTN is consistent with the expected release of blasting residues and timing of the observed increases in some water quality parameters in Mammoth Lake.

Other NF and Downstream Areas – There was no indication of changes in water quality in 2018 relative to baseline conditions at NEM, A20, or the areas downstream from WTS and MAM (A76 and DS1).

Comparison to FEIS Predictions

Management of water in the Whale Tail Pit area and the discharge of effluent to the downstream environment has the potential to change water quality through disturbance of lakes and effluent release. Water quality predictions for Mammoth Lake (and other downstream waterbodies) apply during operations and closure (early and late periods). Comparison of water quality data collected from Mammoth Lake against predictions in the FEIS will be complete annually when the Project enters the operations phase.

Water quality for the Project lakes was not modelled for the construction phase (Golder, 2018). Short-term changes in surface water quality due to blasting were mentioned in the FEIS with a short-to-medium duration and negligible effect on aquatic ecosystems. Based on current concentrations of metals and nutrients in MAM (i.e., < CCME WQGs) the spatial extent of changes in water quality was limited to Mammoth Lake at the end of 2018. A more systematic assessment of the annual water quality data during the construction period is planned for the 2019 CREMP when a full year of ‘after’ data are available for the downstream monitoring locations.

5.4. Phytoplankton Community

Baseline phytoplankton taxonomy data for the Whale Tail study area lakes was summarized in Azimuth (2018b). The baseline report focused on describing the dominant species and seasonal variability in taxonomy metrics (e.g., biomass and richness) within and between areas. The limited data set for the after “impact” period at WTS (August, September and November) and MAM (November) meant there was limited value in formally assessing (i.e., statistical BACI analyses) potential changes in biomass and species richness this year. Rather, plots of the phytoplankton metrics were used to assess whether there is evidence of site-related short-term changes in the phytoplankton community in WTS and MAM after the on-set of construction activities in 2018. Water quality at NEM, A20, A76, and DS1 was unaffected by construction activities in 2018 and are still considered as “control” for future BACI analysis in 2019.

5.4.1. General Observations

The summary of the phytoplankton taxa groups provided in **Section 4.4** for the Meadowbank project lakes applies equally to the lakes within the Whale Tail study area. Six major taxonomic groups of phytoplankton are present in the study lakes, namely blue green algae (*Cyanophyta*), green algae (*Chlorophyta*), golden-brown algae (*Chrysophyta*), diatoms (*Cryptophyta*) and dinoflagellates (*Dinoflagellata*). Species composition varies throughout the year depending upon water temperature, nutrient concentration, time of year, water clarity and amount of sunlight, and predation by zooplankton. The biomass of the phytoplankton community was predominately comprised of chrysophytes (golden-brown algae) at most areas and seasons in the data collected between 2015 and 2017 (**Figure 5-41**). Seasonally, chrysophyte biomass was highest in the summer months and lowest in spring and late fall/winter during the baseline period (Azimuth 2018b). Seasonally variability in was evident among other taxa groups with chlorophytes more abundant in the summer months and crytpophytes and diatoms more dominant in the winter sampling events (March – May, November; **Figure 5-41**).

5.4.2. Temporal and Spatial Trends

Tabulated phytoplankton community data from the 2018 CREMP are presented in **Appendix D2**.

The approach to identify potential mine-related impacts involved visually examining metrics for primary productivity and community composition for evidence of temporal-spatial patterns that might be associated with mine-related activities outlined in **Section 5.1** and **Table 1-1**. Plots of the phytoplankton metrics were used to interpret seasonal and annual variations in community composition. The metrics used to assess changes in the community were chlorophyll-a (**Figure 5-38**), total biomass (**Figure 5-39** to **Figure 5-41**) and species richness (**Figure 5-42**). Supplemental plots showing major taxa group biomass (mg/m^3) and density (mg/L) are included in **Appendix D**. Key results are discussed below:

Primary Productivity – There was no indication of changes in primary productivity in the Whale Tail study area lakes in the 2018 based on the chlorophyll-a concentrations in surface water (**Figure 5-38**) or total biomass estimates from the taxonomy analysis (**Figure 5-39**). Chlorophyll-a concentrations were typically less than 1 µg/L. indicative of oligotrophic systems (Kasprzak et al. 2008) and representative of baseline trophic status in the various lakes. Total biomass was highest for the July 8th sampling event with ~400 mg/m^3 at measured in WTS and ~350 mg/m^3 and MAM. These data are at the upper end of the range reported in the 2015 to 2017 data. Overall there is no evidence of changes (e.g., increases due to inputs from blasting or other activities) in primary productivity in the near-field areas (MAM and WTS) due to construction activities in 2018.

Community Composition – The number of taxa measured varies by season, with a more diverse community present during the open water season compared to when ice covers the lakes. The pattern of seasonal variability in species richness observed in 2018 was similar to previous years for the various lakes (**Figure 5-42**). Over 30 different species of phytoplankton are typically present during the open water season. At WTS, the richness in August and September ranged from 27 to 31. By comparison, the 2017 results for August were 33 and 34 taxa. While subtle construction-related changes in phytoplankton diversity in WTS cannot be ruled out, it seems unlikely given the minor changes in water quality observed and the lack of change to phytoplankton biomass. These results suggest that dike construction and associated changes in water quality were not adversely affecting the diversity of the phytoplankton community in WTS.

Effects, in the context of the CREMP, are evaluated based on changes in total biomass and species richness. On-going monitoring scheduled for 2019 will help determine if there are changes in total biomass and species richness that exceed the trigger value of 20% or threshold of and 50% effects relative to the baseline/reference conditions.

5.5. Sediment Chemistry

5.5.1. General Observations

Lake sediments in the Project area are generally similar to those described for the Meadowbank lakes in **Section 4.5.1**. Key points to consider are:

- Natural sedimentation rates in these headwater lakes are low. However, there are a number of development-related activities that can increase sediment loading to the lakes.
- Sediments are generally dominated by silt and clay fractions. Particle size distribution in sediment grab samples (top 3-5 cm of sediment surface) is predominantly silt and clay, characteristic of depositional areas in all the lakes sampled in this region (**Figure 5-43**).
- Lakes within the Project area are enriched in some metals compared to CCME sediment quality guidelines (SQGs). Arsenic, cadmium, chromium, copper, and zinc exceeded the interim sediment quality guideline (ISQG[23]) in at least one sample collected in 2018. Exceedances of the probable effect level (PEL)[24] screening criteria were limited to arsenic (all areas) and chromium at MAM, A76, and NEM. Arsenic is particularly enriched in sediments throughout the study area. Concentrations measured in 2018 exceeded the ISQG in 100% of samples and exceeded the PEL in 25/30 samples. The highest reported concentrations were measured at WTS and A20 (~ 150 mg/kg dw), but as seen in **Figure 5-44**, there is considerable within-area variability in sediment metals concentrations reported on an

[23] The ISQG is equivalent to the threshold effect level (TEL): calculated as the geometric mean of the lower 15th percentile of the effect data set and the 50th percentile of the no-effect data set (CCME, 1999).

[24] The PEL is the lower limit of the range of chemical concentrations that is usually or always associated with adverse biological effects.

annual basis. Heterogeneity in sediment metals concentrations over a small spatial scale is common in areas of natural mineralization and has previously been documented under baseline conditions for lakes monitored as part of the Meadowbank CREMP (Azimuth 2015b).

5.5.2. Temporal and Spatial Trends

Baseline sediment chemistry data collected between 2015 and 2017 were summarized in the comprehensive baseline CREMP report Azimuth (2018b). Formal statistical analysis of changes in sediment chemistry are done on a 3-year cycle in years when sediment coring (and EEM) is completed. Baseline coring data were collected in 2017 and the first cycle of before-after (BA) statistical analysis is scheduled for the 2020 CREMP. In years when coring isn't completed, sediment concentrations in the grab samples are visually examined for potential changes over time. Sediment grab samples are collected to characterize the habitat (grain size and TOC) and metals concentrations that are relevant for assessing the exposure conditions for the benthos community.

Tabulated sediment grab chemistry data from the 2018 CREMP, screened against the Meadowbank triggers/thresholds, are presented in **Appendix C2**.

Sediment chemistry from 2015 to 2018 is shown in **Figure 5-44** to **Figure 5-50** for the metals with CCME SQGs. Note that the data are shown compared to the trigger values that were updated for the Meadowbank project lakes in 2017[25]. The focus for sediment was on WTS only as it was the only area associated with construction activities when sampling was conducted in August. None of the metals at showed any increases relative to the range observed during the baseline period, which is not unexpected considering that dike construction activity in Whale Tail Lake started just prior to sampling. Furthermore, the mitigation measures appear to have functioned well in limiting particulate loading to WTS as evidenced by good overall water quality reported during dike construction monitoring (R. Allard, pers comm, November 2, 2018).

Hydrocarbon concentrations were less than the detection limits for all analytes measured in the composite samples from 2018. Elevated detection limits were reported for a number of analytes due to naturally-high moisture content in the sediments. In most cases, the lowest reported detection limit was below the ISQG; however, WTS, MAM, A20 and INUG had detection limits for acenaphthylene, chrysene, and dibenz(a,h)anthracene that were greater than their respective ISQGs. The DLs were below the PEL concentration in all instances. High moisture content has periodically resulted in elevated reporting limits for hydrocarbon in the baseline

[25] Site-specific trigger values will be developed prior to the 2020 field program to assess temporal changes in sediment core chemistry data.

Whale Tail CREMP and annual Meadowbank CREMP. We are working in conjunction with ALS on ways to improve reporting limits for hydrocarbons and PAHs in 2019.

In summary, sediment chemistry results for 2018 were generally consistent with previous years and showed no indications of construction-related changes.

5.6. Benthos Community

5.6.1. General Observations

Benthos abundance can vary widely for a given lake on an annual basis, and multiple years of baseline data help define the normal range of variability in benthos abundance among the areas. Richness tends to be relatively stable year-over-year. The relative proportions of various taxa may vary, but the number of taxa is consistent throughout the baseline period and start of construction. Abundance (organisms/m^2) and richness (# unique taxa) of benthic invertebrates is calculated for each replicate and study year. Abundance and richness of benthos were characteristic of depositional areas in northern lakes with low productivity and nutrient cycling. Insects, primarily chironomids in the subfamilies Chironominae and Tanypodinae, and fingernail clams (Sphaeriidae) were the dominant benthic invertebrate taxa in the Whale Tail study area lakes (Azimuth 2018a).

5.6.2. Temporal and Spatial Trends

The methods and approaches to assessing benthic invertebrate (benthos) community metrics described for the Meadowbank CREMP apply for the Whale Tail Program. As the Project transitions from baseline to construction / operations, changes in benthos abundance and richness will be evaluated using the same BACI study design outlined in **Section 2.4.3**. Formal BACI analysis of the benthos data was deferred until 2019. Dike construction started on July 27th, approximately three weeks prior to benthos sampling in the area. Changes in sediment quality at WTS as a result of dike construction were considered unlikely, but because of the proximity of the sediment/benthos area to the Whale Tail dike, the area designation was changed from “control” to “impact” in 2018. The timing of road construction and development of Quarry 2 in vicinity of Mammoth Lake after benthos sampling in August justified keeping MAM, and the other downstream areas in “control” status for 2018.

Summary results for major taxa group abundance and richness in 2018 are presented in **Appendix E2** along with supplemental plots showing abundance and richness at the major taxa group level since the start of baseline sampling. Plots of the key metrics (i.e., abundance and richness) were used to assess spatial and temporal trends for the Whale Tail study area lakes (**Figure 5-51** to **Figure 5-56**). Key results for 2018 were as follows:

Abundance – Total benthos abundance is highly variable within the lakes and among years. In a very general sense, the normal range in mean total abundance across years among the 6 study areas is roughly 2,000 to 5,000 organisms/m^2 (**Figure 5-51**). Estimates of total abundance at the periphery of this range were common throughout the baseline phase, but only a few samples had fewer than 1,000 organisms/m^2. Compared to the reference areas INUG and PDL, the Whale Tail study area lakes appear to be slightly more productive and more variable. Benthos data from A76 in 2017 typifies the high spatial variability in benthos abundance that occurs in these northern lakes. Estimated total abundance in two replicates from A76 in 2017 were 14,000 and 24,000 organisms/m^2 compared to approximately 3,000 organisms/m^2 in the other three replicates (**Figure 5-51**). The spike in abundance in these two replicates was due mainly to increased abundance of three species: *Corynocera ambigua*, *Paratanytarsus sp*., and *Tanytarsus sp*.

Benthos abundance reported in the 2018 samples were within the range reported during the baseline period for all six lakes. Mean abundance (n=5 replicates) at WTS in 2018 was 5,000 organisms/m^2. By comparison total abundances in 2017, 2016, and 2015 were 4,500, 2,500 and 1,800 organisms/m^2, respectively. As expected, dike construction did not adversely affect benthos abundance in WTS in 2018. Reported total abundance at the other study areas in 2018 were within the ranges reported previously for each location.

Taxa Richness – The same assemblage of various taxa observed at the Meadowbank project lakes were documented during the baseline period for the Whale Tail study area lakes. Unlike abundance, taxa richness was less variable within and among areas on an annual and inter-annual basis (**Figure 5-54**). Taxa richness at the lowest practical level is typically between 10 and 15 taxa in the Whale Tail study area lakes, with insects dominating in both number of taxa (**Figure 5-55**) and proportion of the total sample abundance (**Figure 5-53**). Molluscs are the next most dominant taxa group in terms of the number species and total abundance, particularly when the abundance of insects and other taxa groups are low (Azimuth 2018a). Taxa richness at WTS was highest in 2018 (13 to 20 taxa), providing further proof that dike construction did not adversely affect the benthos community at WTS in 2018.

5.6.3. Sediment Metals Bioavailability Study Results

Sediment toxicity tests were conducted using *Chironomus dilutus* and *Hyalella azteca* to evaluate the baseline sediment toxicity test results for the Whale Tail Project according to the same methods described for TPE and WAL (**Section 4.6.3**). The two study areas chosen for baseline toxicity testing (MAM and WTN) are naturally enriched, but variable, in the reported concentrations of arsenic: MAM (48 – 75 mg/kg) and WTN (76 – 705 mg/kg). INUG and PDL served as the field controls to compared survival and growth responses in the MAM and WTN treatments. Survival (%) and growth (mg/organisms [dw]) results are presented in **Table 5-3** for *C. dilutus* and **Table 5-4** for *H. azteca*. Key results are described below.

Chironomid Survival and Growth – No difference was observed in *C. dilutus* survival or growth for MAM or WTN relative to the laboratory or field control treatments (**Table 5-3**). Mean survival was 84% for MAM and 90% for WTN. Growth (mg/organism [dw]) was slightly higher for the MAM treatment compared to the pooled data from INUG and PDL and similar for WTN compared to the control treatments.

Amphipod Survival and Growth– No difference was observed in *H. azteca* survival among the various treatments. There was a significant reduction in amphipod dry weight from the WTN treatment compared to the laboratory control ($p < 0.001$), INUG ($p = 0.0013$), and PDL ($p < 0.001$) at the end of the 14-d test. The reduction in amphipod growth corresponded to a 40% effect relative to the pooled dry weight data from the INUG and PDL field control treatments (**Table 5-4**).

Baseline Sediment Toxicity – Based on bulk sediment chemistry, the most likely stressors in MAM and WTN sediments are arsenic and chromium, both of which exceeded the CCME PEL in all five replicate samples. At WTN, arsenic concentrations exceeded the PEL of 17 mg/kg by approximately 35 to 40-fold in three of the replicate samples[26] (rep 1 [668 mg/kg], rep 2 [620 mg/kg], and rep 4 [705 mg/kg]) without any effect to chironomid growth or survival. Lower amphipod dry weight was reported in reps 1, 2, and 4 (0.06 – 0.10 mg [dw]). Arsenic in rep 3 and 5 was considerably lower at 76 mg/kg and 366 mg/kg, respectively. Amphipod dry weight was higher in these two replicate samples (0.14 mg and 0.17 mg [dw]) and more in line with the range reported for the field control treatments (0.14 mg and 0.22 mg). These data suggest that if future sediment concentrations in the Whale Tail study area lakes approach levels representative of WTN, and if bioavailability remains similar to baseline conditions, sub-lethal effects to amphipod growth are *plausible*. Chironomids, meanwhile, appear inherently less sensitive to concentrations of arsenic and other metals characteristic of the baseline conditions in the Whale Tail study area lakes.

The toxicity test results demonstrate how exceedances of sediment quality guidelines or screening criteria, particularly in highly mineralized regions, need to be interpreted cautiously with respect to the potential risk to benthos community endpoints (abundance and richness).

[26] Metals concentrations were measured on a subsample of the homogenized sediment, not on the sediments used for toxicity testing. Conditions in the test chambers are inferred from the analytical data provided by ALS for each replicate sample (see **Appendix C** for the sediment chemistry data from 2018).

5.7. Whale Tail Tables and Figures

The tables and figures for the Whale Tail study areas provided in this section except for the large tabulated datasets and figures for parameters that are not included in the detailed analysis (see in-text references to appropriate Appendices). Subsections are provided for each of the CREMP components (e.g., limnology, water chemistry, phytoplankton, sediment chemistry, and benthos).

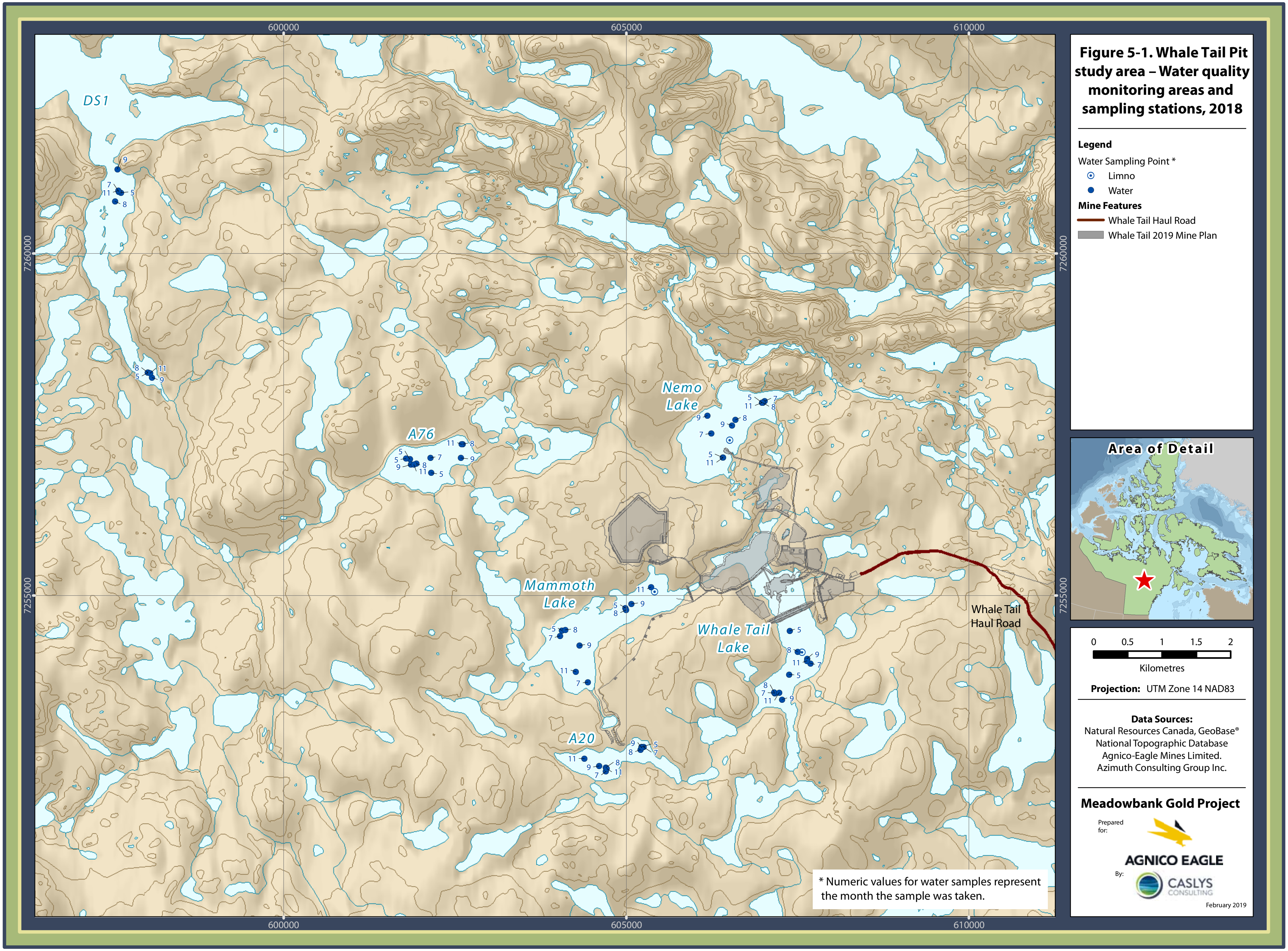
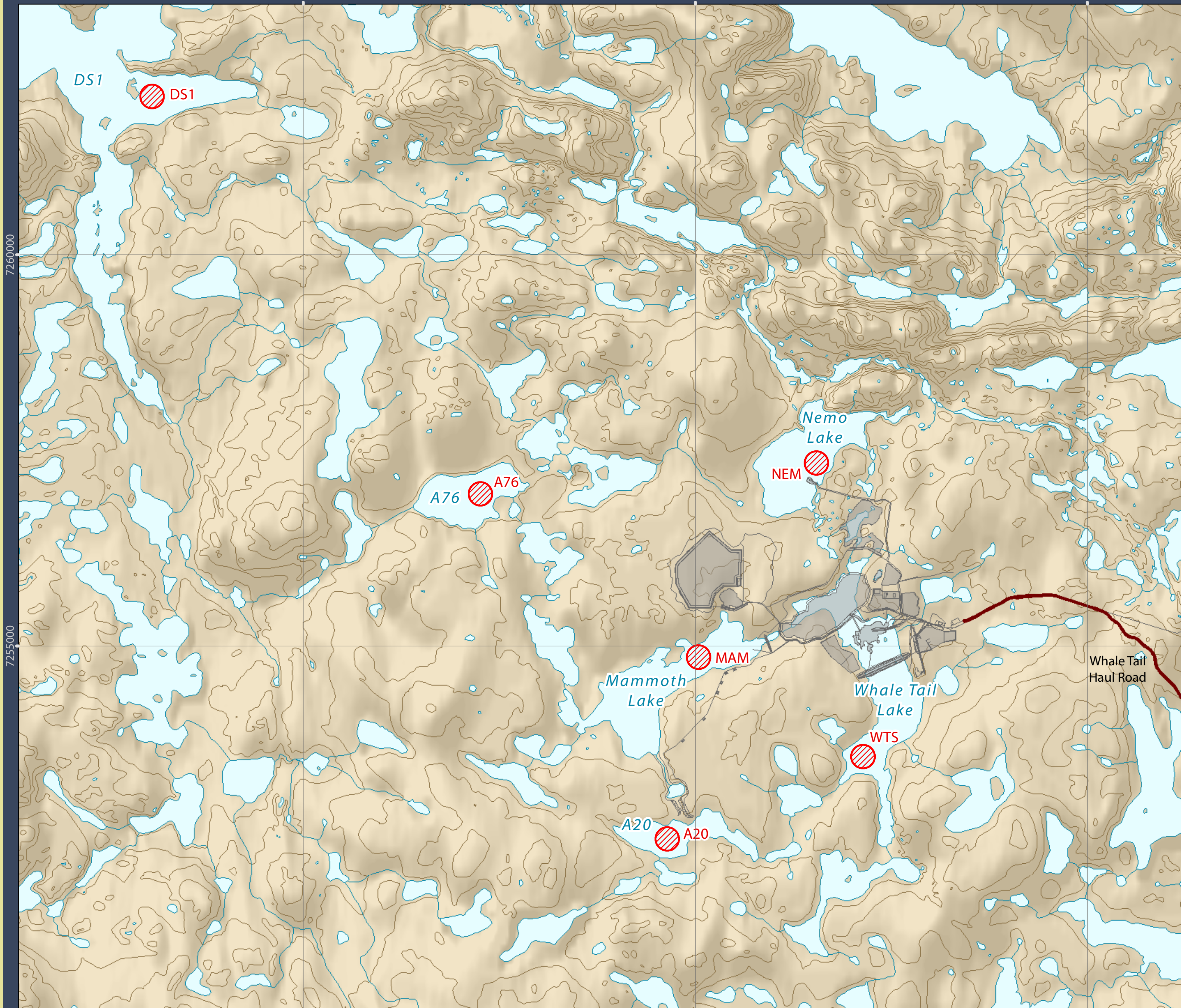


Figure 5-1. Whale Tail Pit study area – Water quality monitoring areas and sampling stations, 2018

Figure 5-2. Whale Tail Pit study area – Sediment and benthic invertebrate areas, 2018



Legend

Sediment/Benthic Invertebrate Quality Sampling Station

Mine Features

Whale Tail Haul Road

Whale Tail 2019 Mine Plan

0 0.5 1 1.5 2

Kilometres

Projection: UTM Zone 14 NAD83

Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.

Meadowbank Gold Project

Prepared for:

AGNICO EAGLE

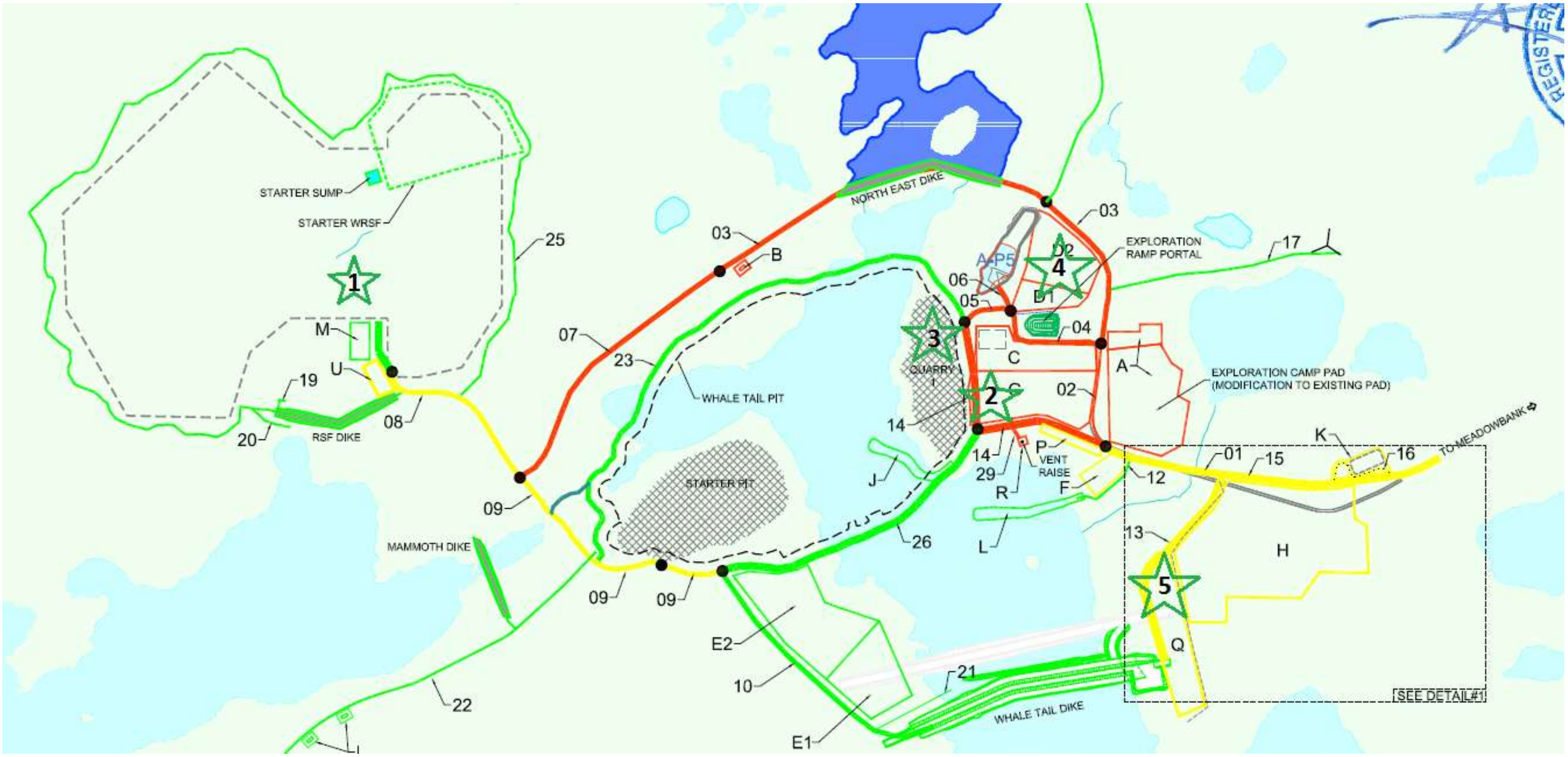
By:

CASLYS CONSULTING

February 2019

Figure 5-3. Amaruq mine plan showing the location of the Whale Tail Dike and other site infrastructure.

Note: Road 9 (in yellow) leads from Quarry 2 to the future location of the waste rock storage facility north of Mammoth Lake.



Limnology Tables and Figures

Figure 5-4. Mean monthly field-measured temperature (°C) at 3 m depth from 2014 – 2018, Whale Tail study area lakes.

Note: The first sampling event was completed in September 2014.

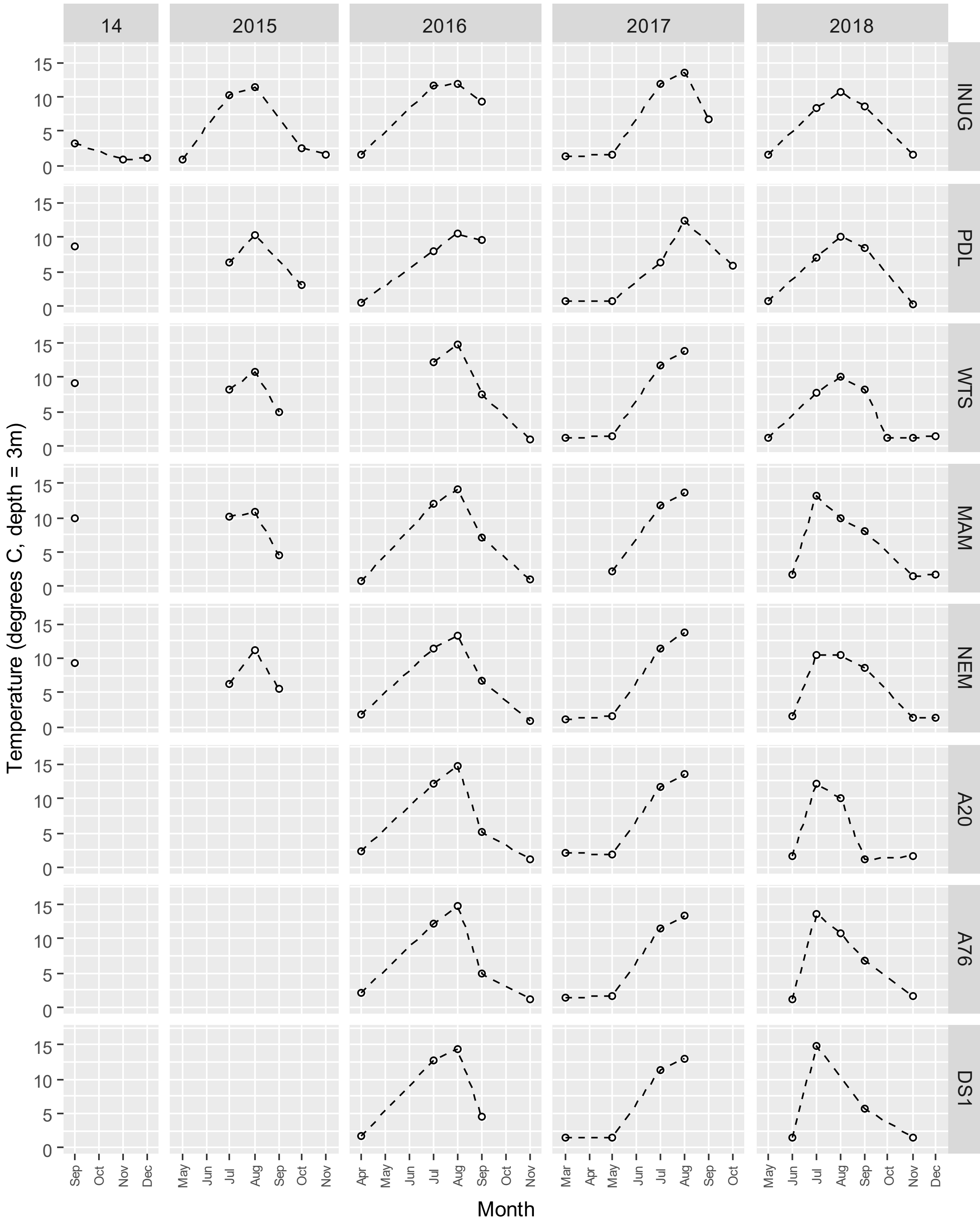
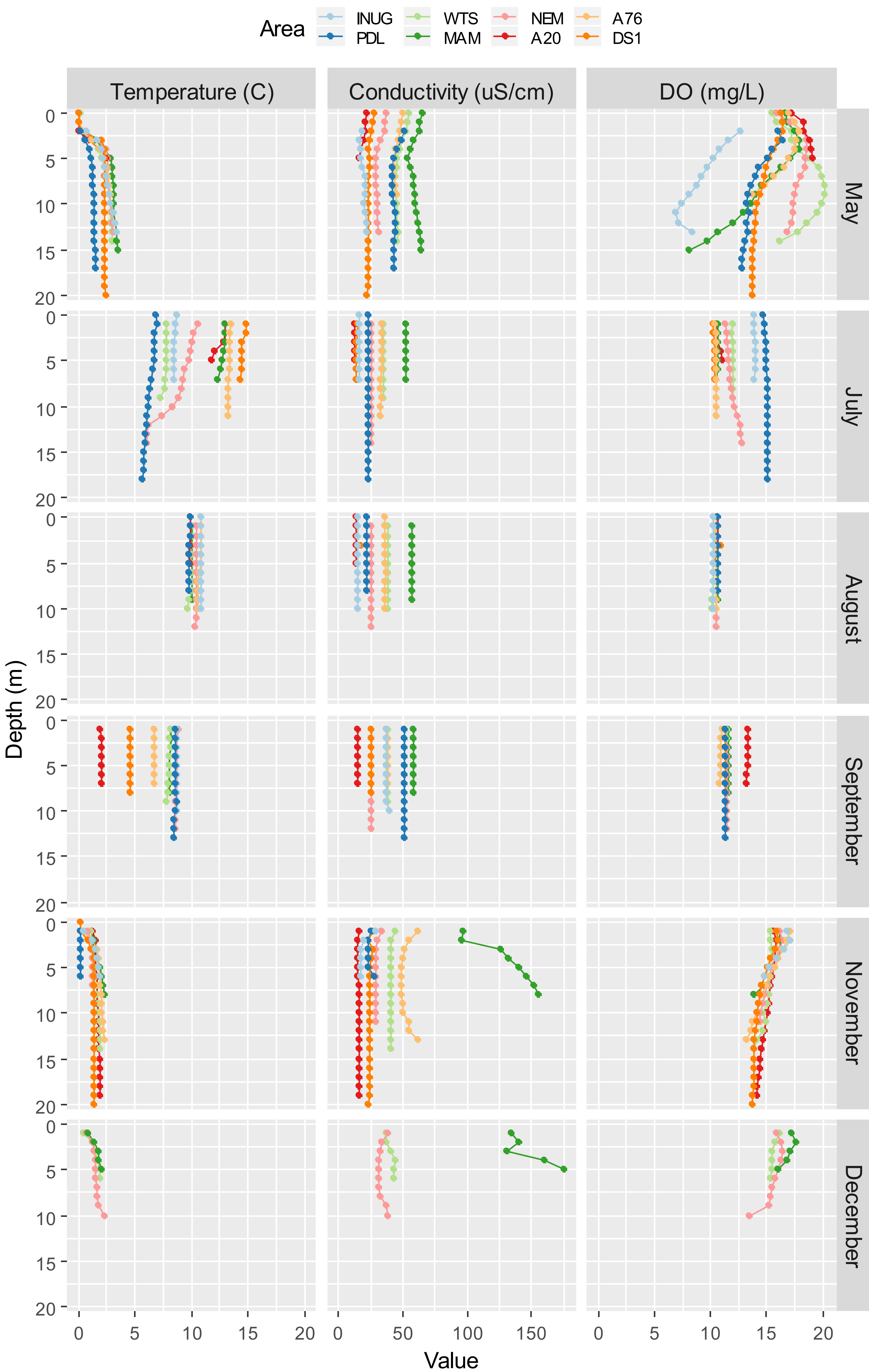


Figure 5-5. Whale Tail – Field-measured temperature (°C), conductivity (µS/cm) and dissolved oxygen (mg/L) profiles, 2018.



Water Chemistry Tables and Figures

Figure 5-6. Laboratory-measured conductivity (µS/cm) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

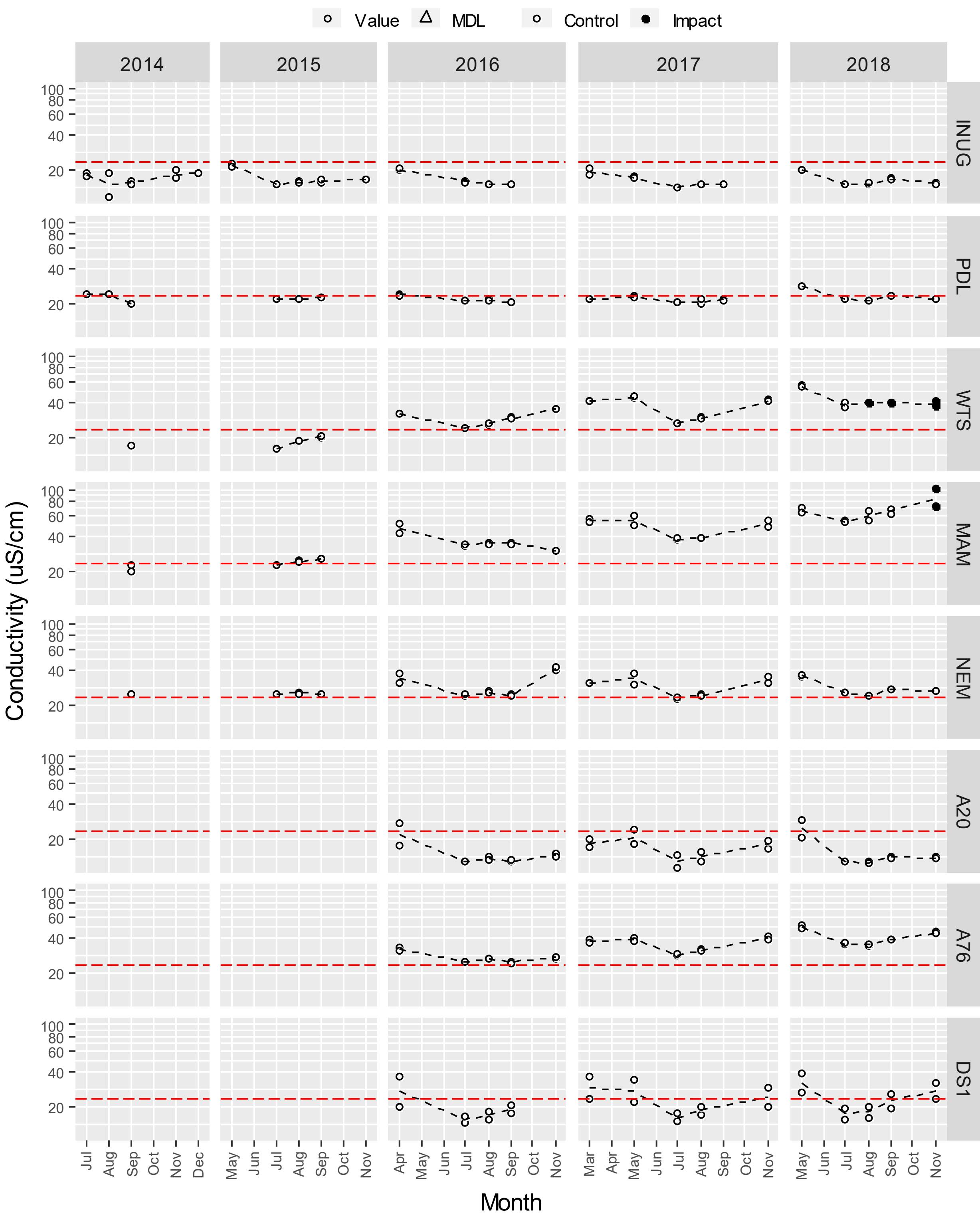


Figure 5-7. Hardness (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

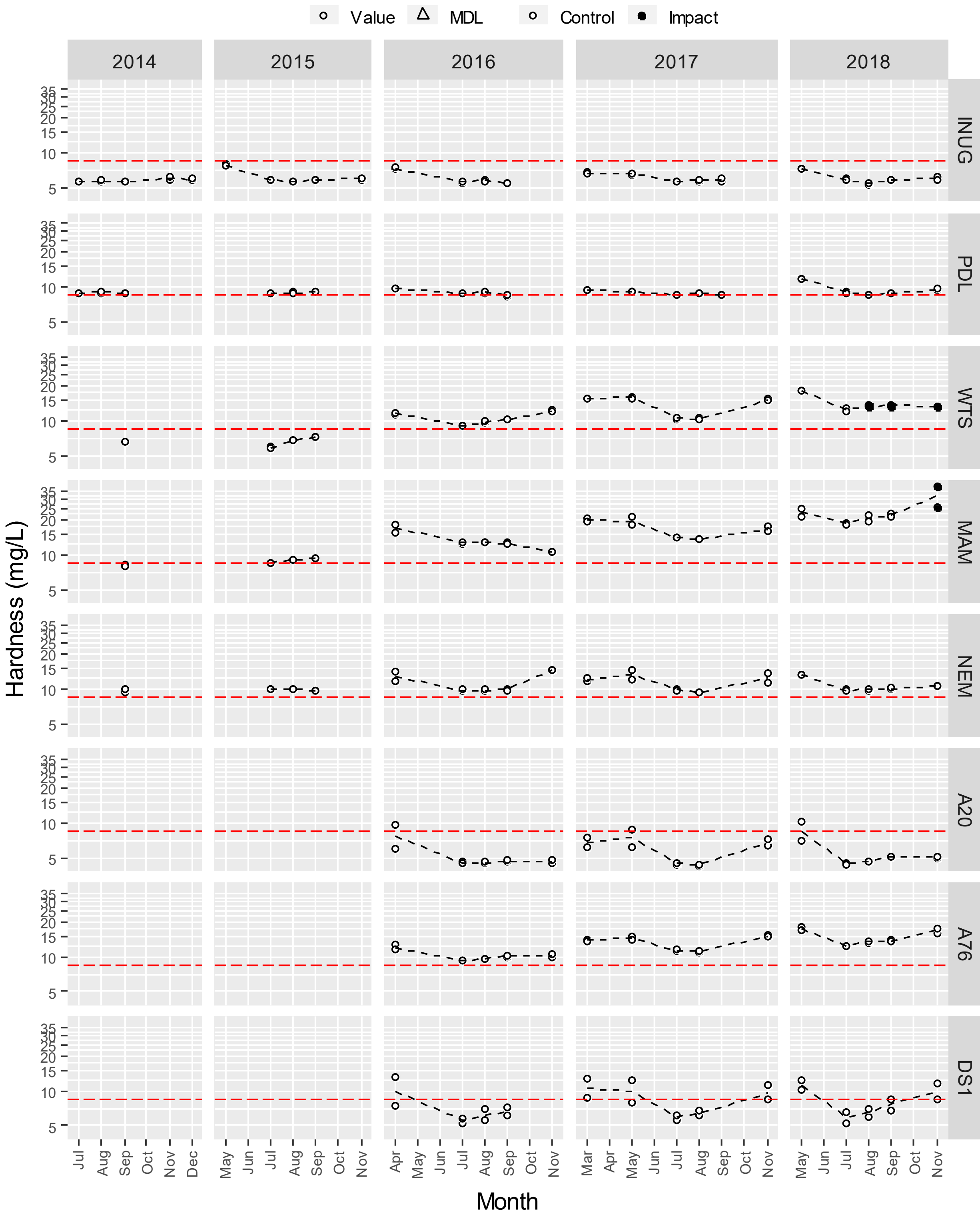


Figure 5-8. Field-measured pH in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

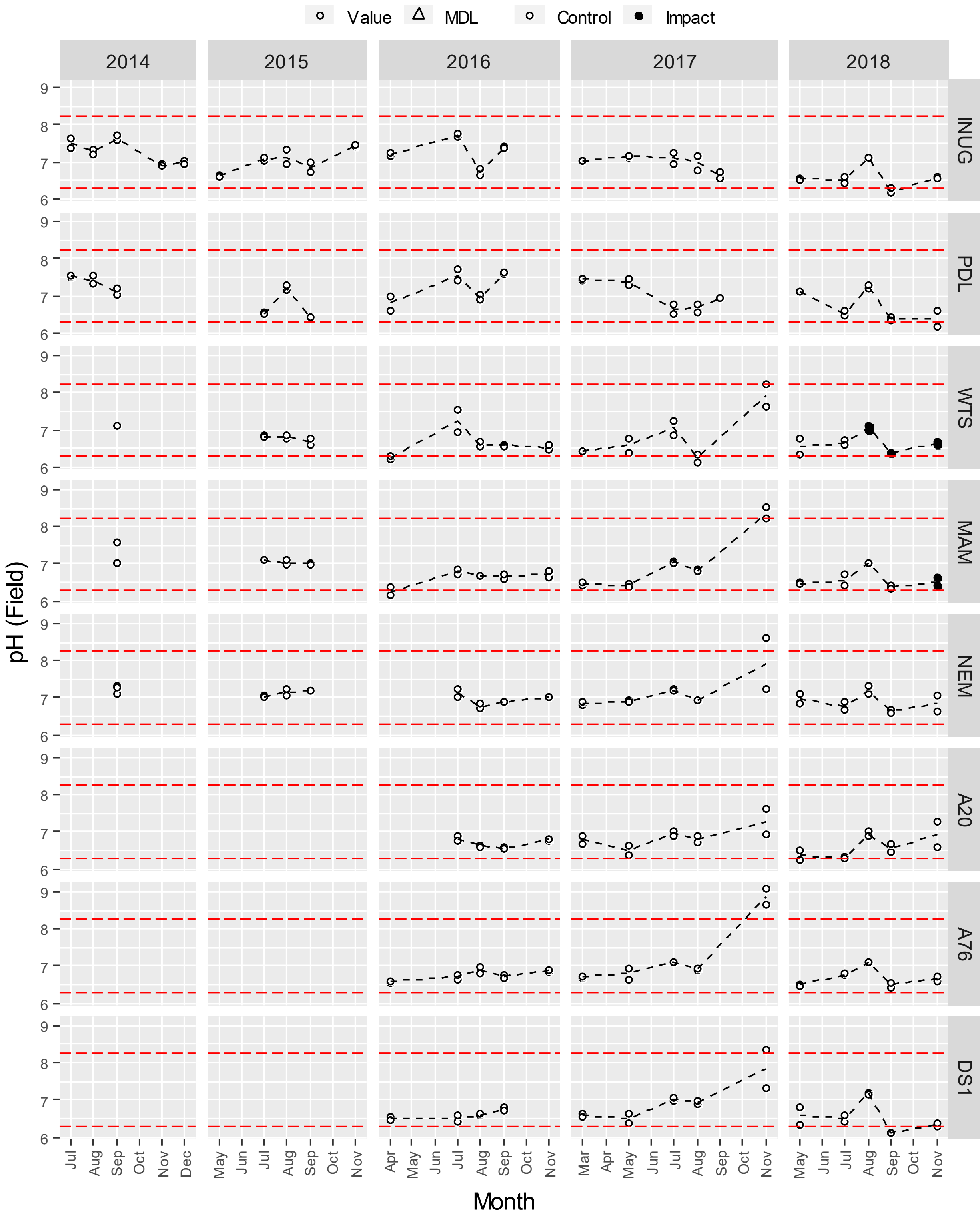


Figure 5-9. Laboratory-measured pH in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

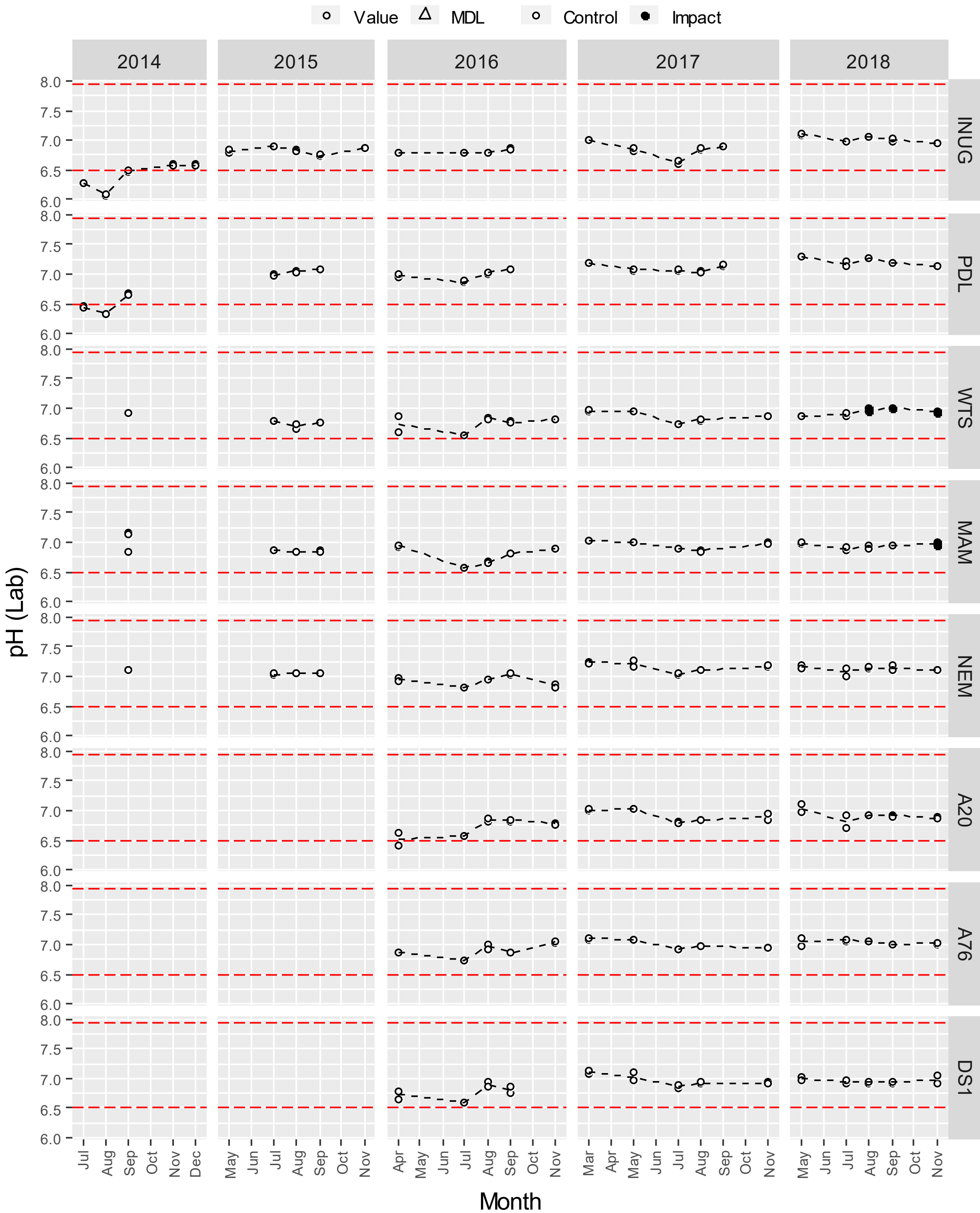


Figure 5-10. Total Suspended Solids (TSS; mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context. Sept '14 INUG sample omitted from analysis.

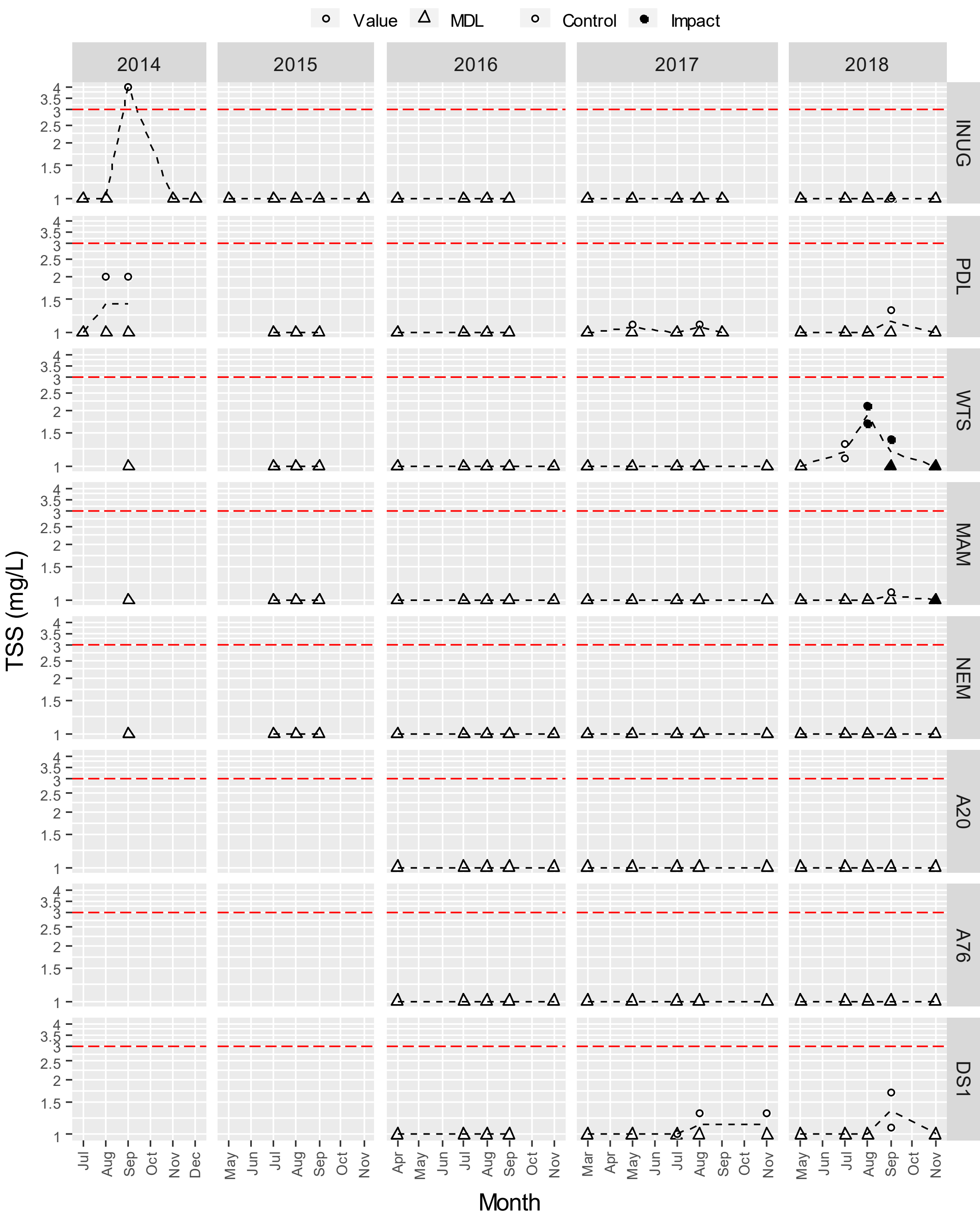


Figure 5-11. Total Dissolved Solids (TDS; mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

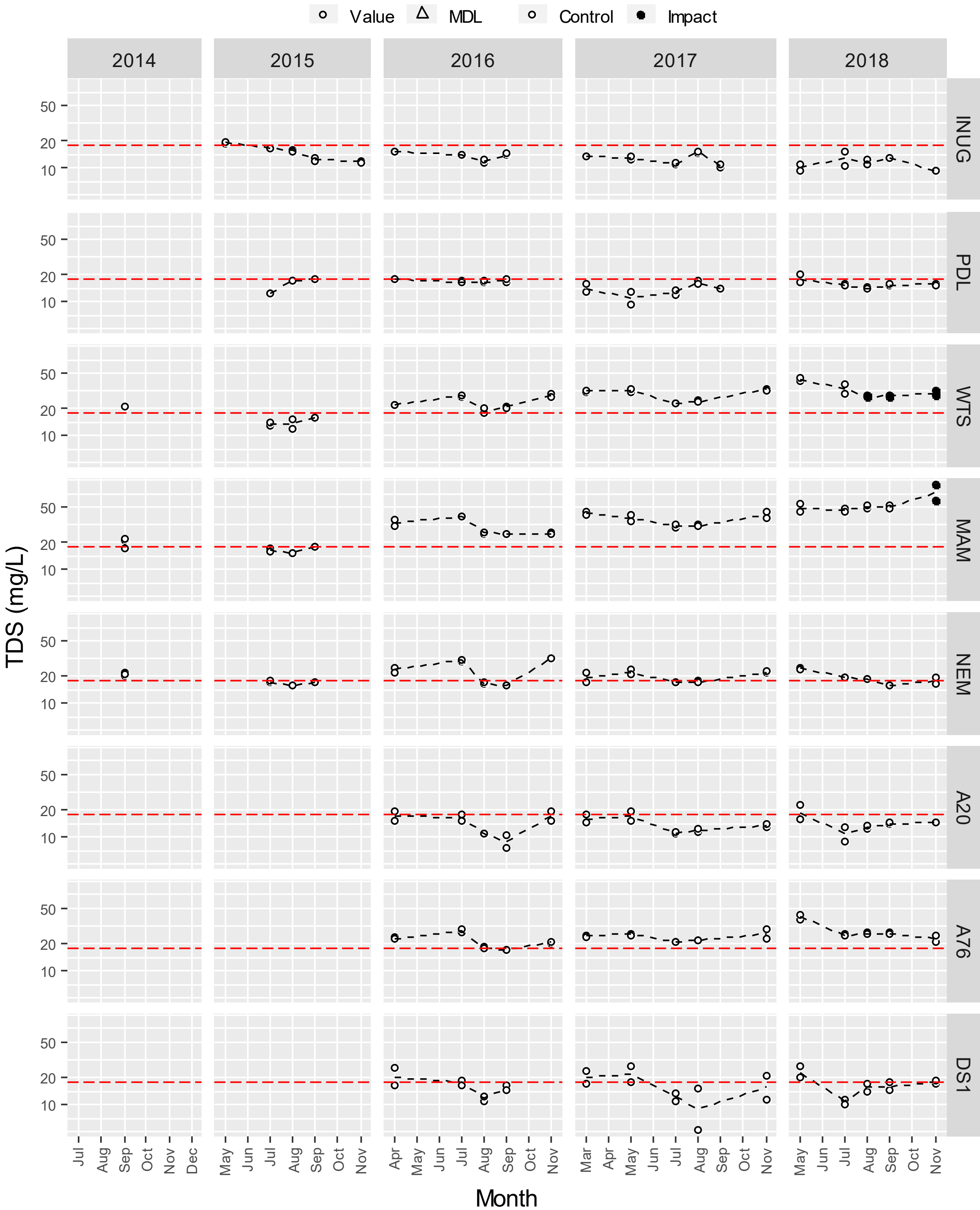


Figure 5-12. Bicarbonate alkalinity (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

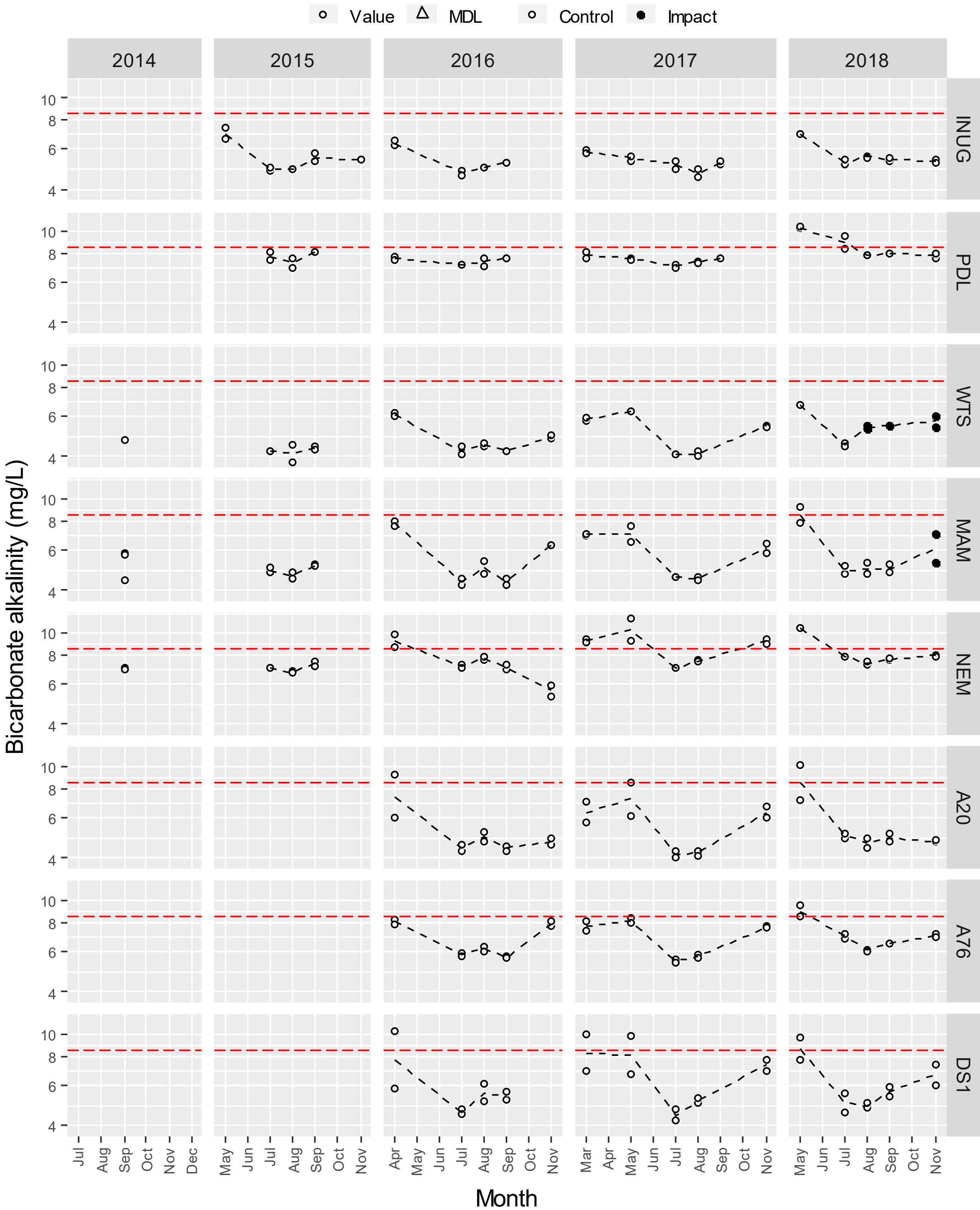


Figure 5-13. Ammonia-N (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

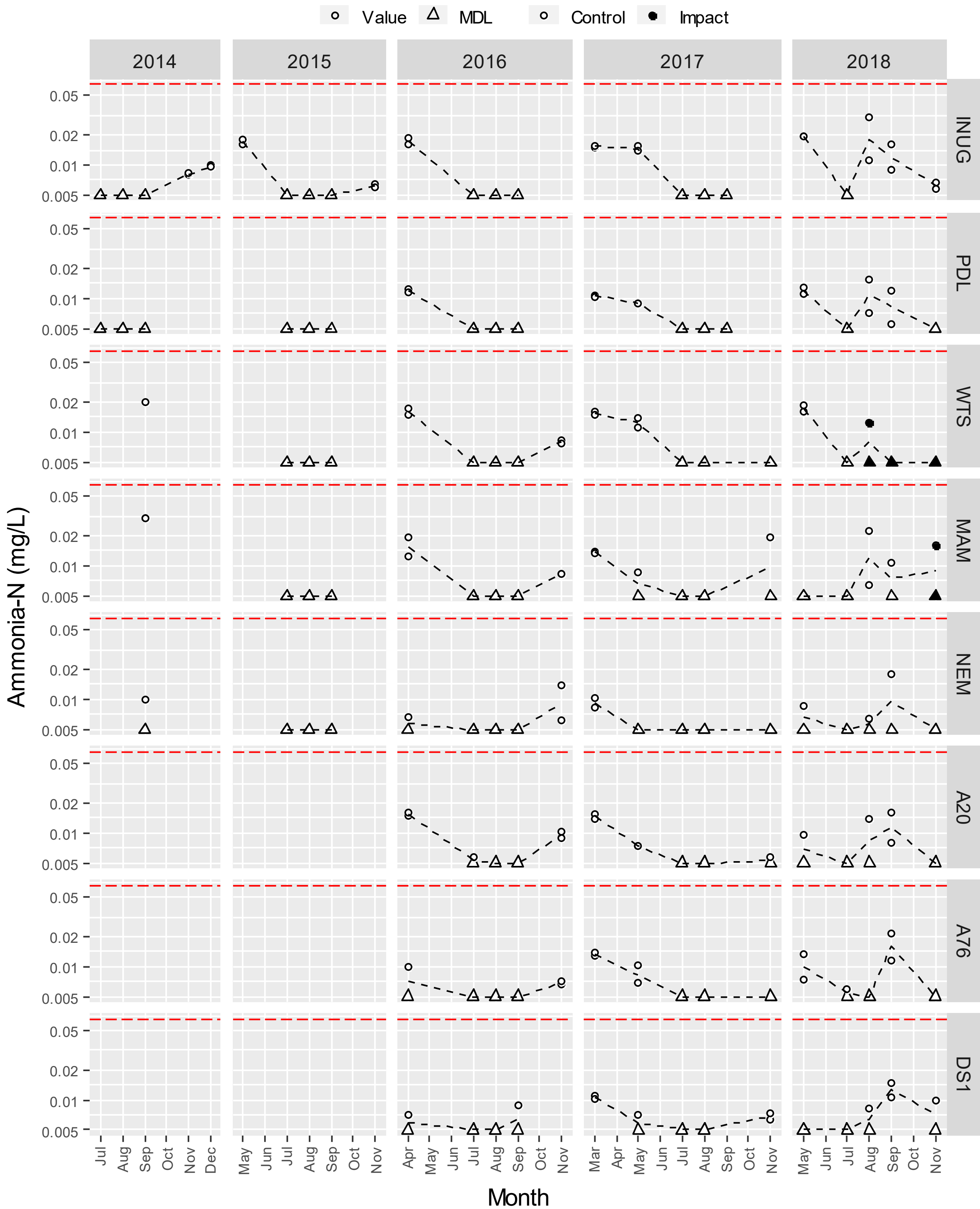


Figure 5-14. Chloride (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

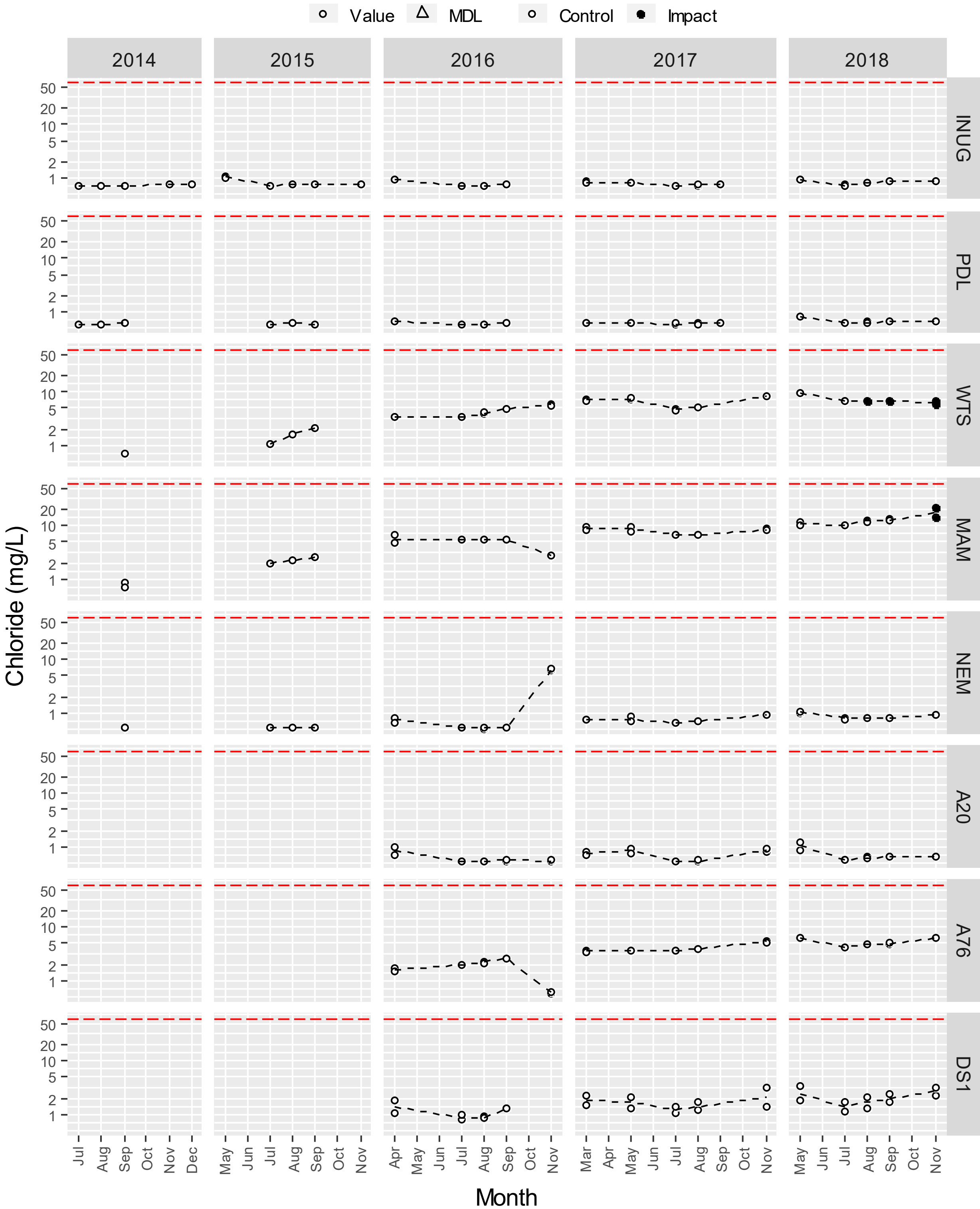


Figure 5-15. Nitrate (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

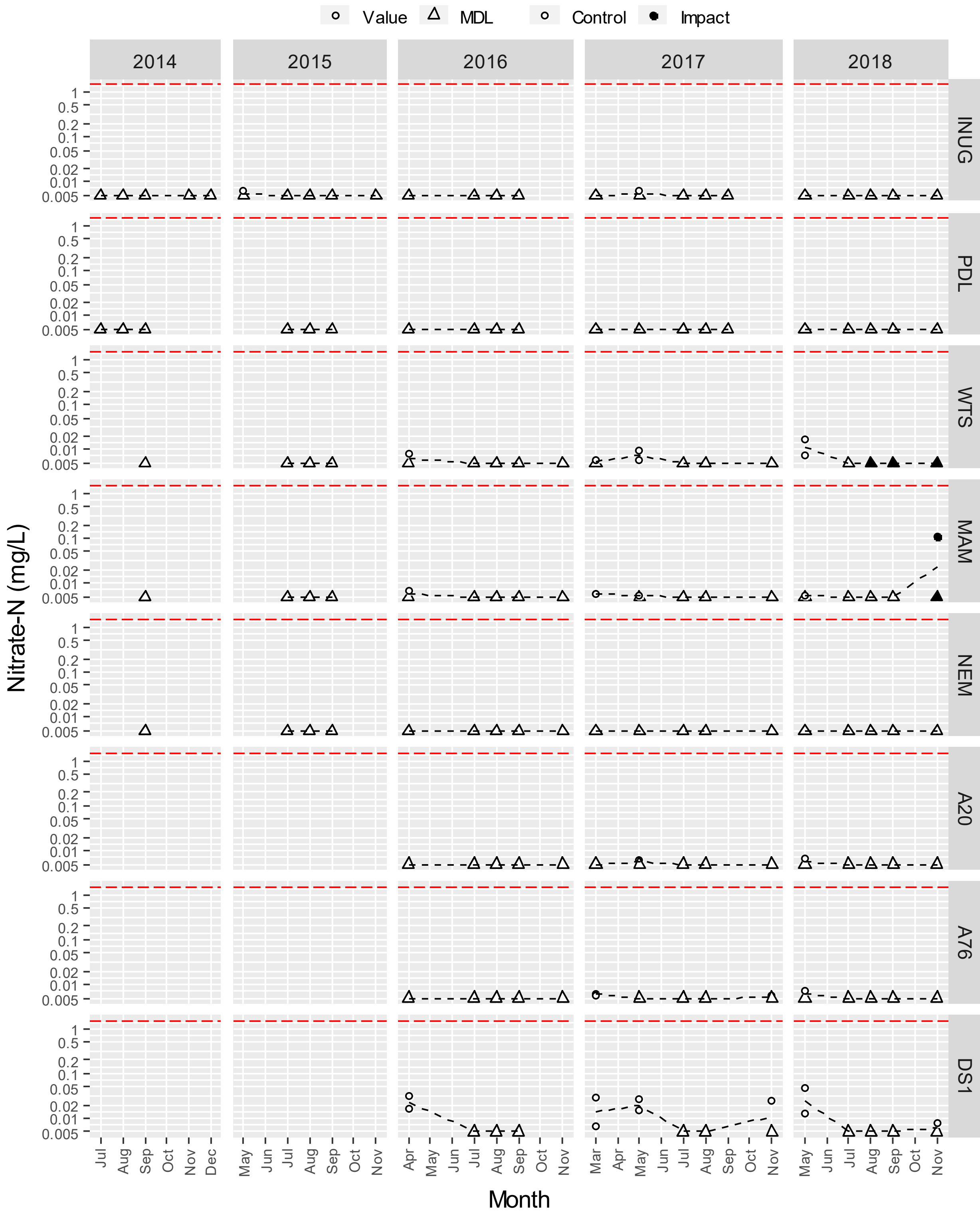


Figure 5-16. Nitrite (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

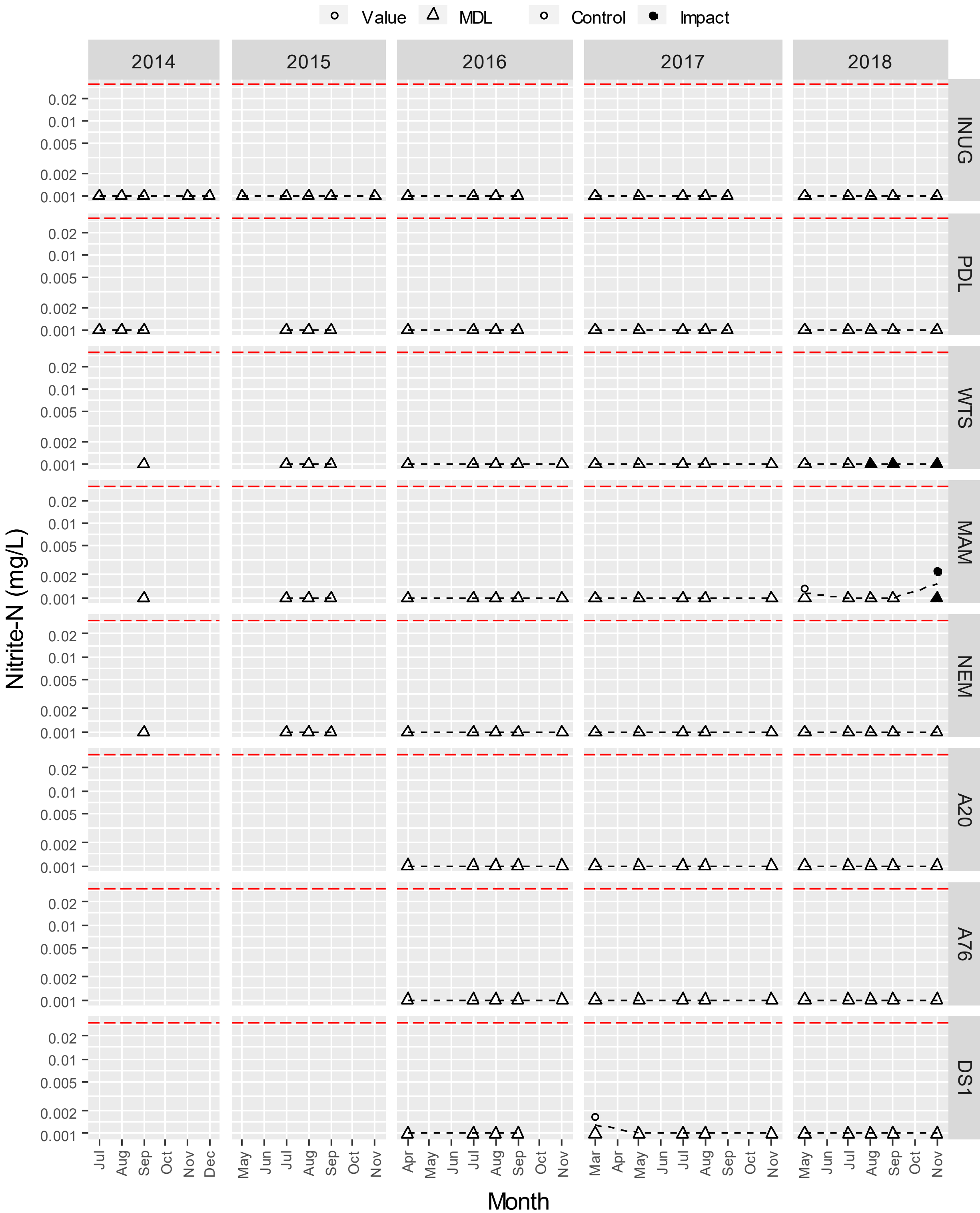


Figure 5-17. Total Kjeldahl Nitrogen (TKN; mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

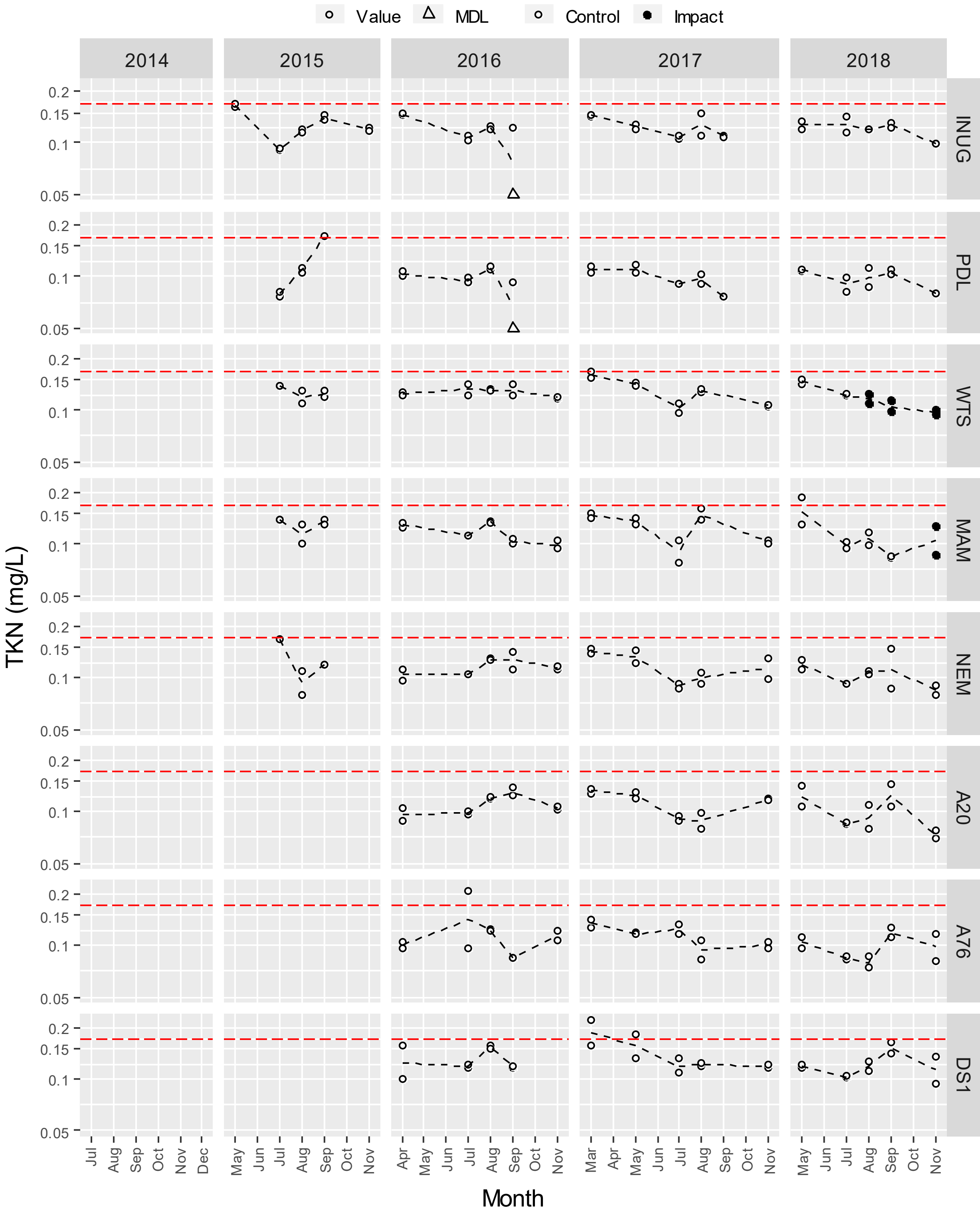


Figure 5-18. Total phosphorus (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

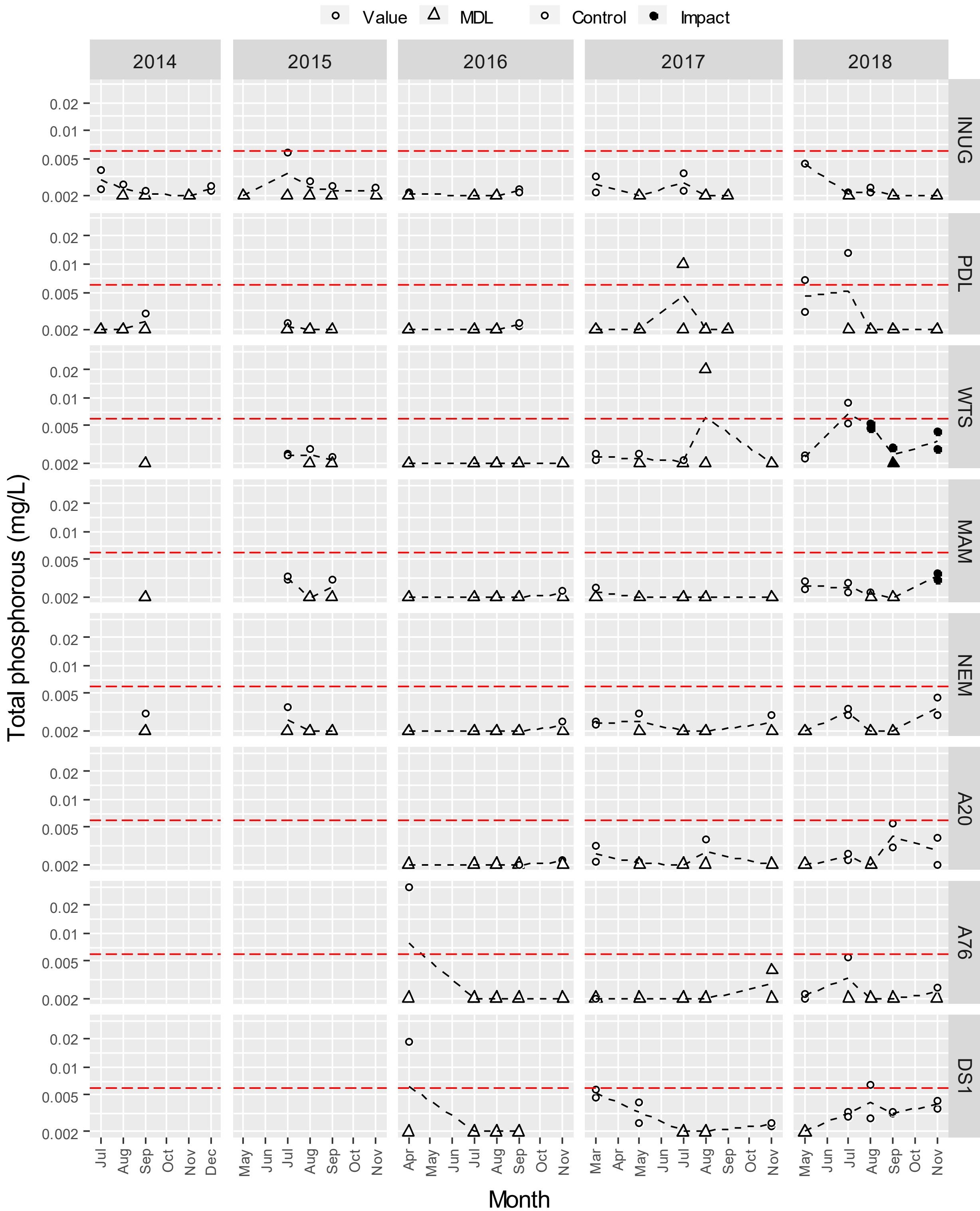


Figure 5-19. Sulphate (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

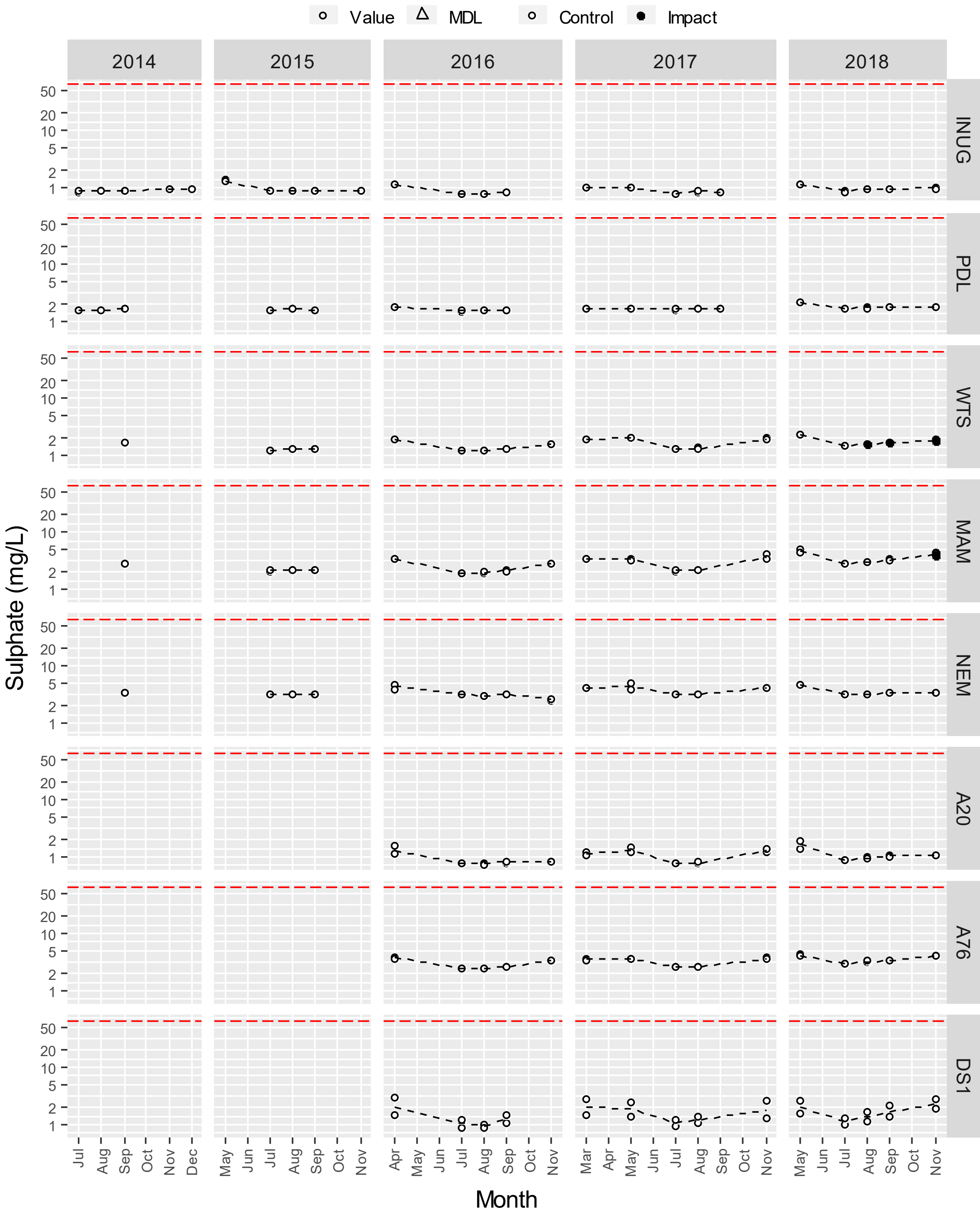


Figure 5-20. Dissolved organic carbon (DOC; mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

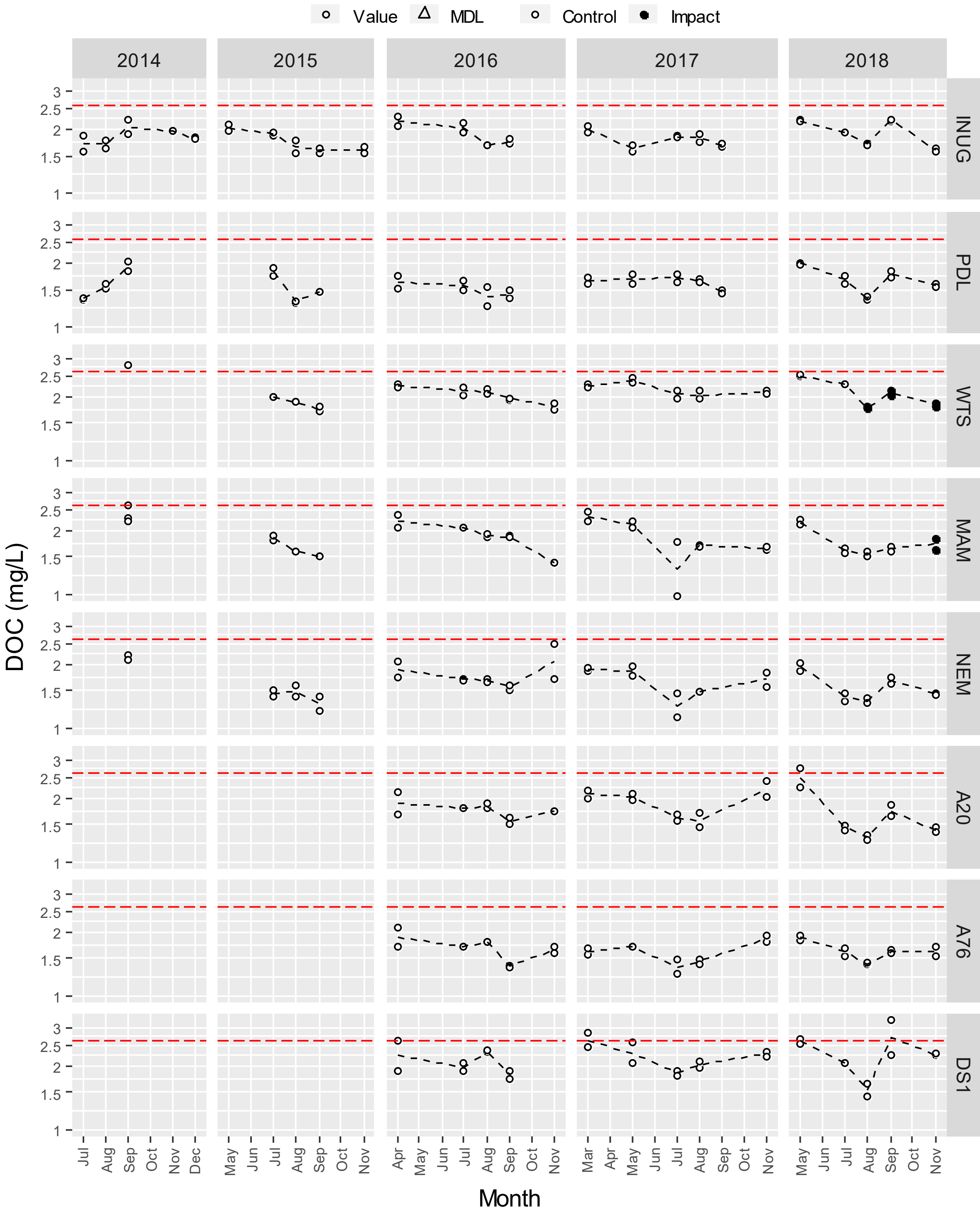


Figure 5-21. Total organic carbon (DOC; mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

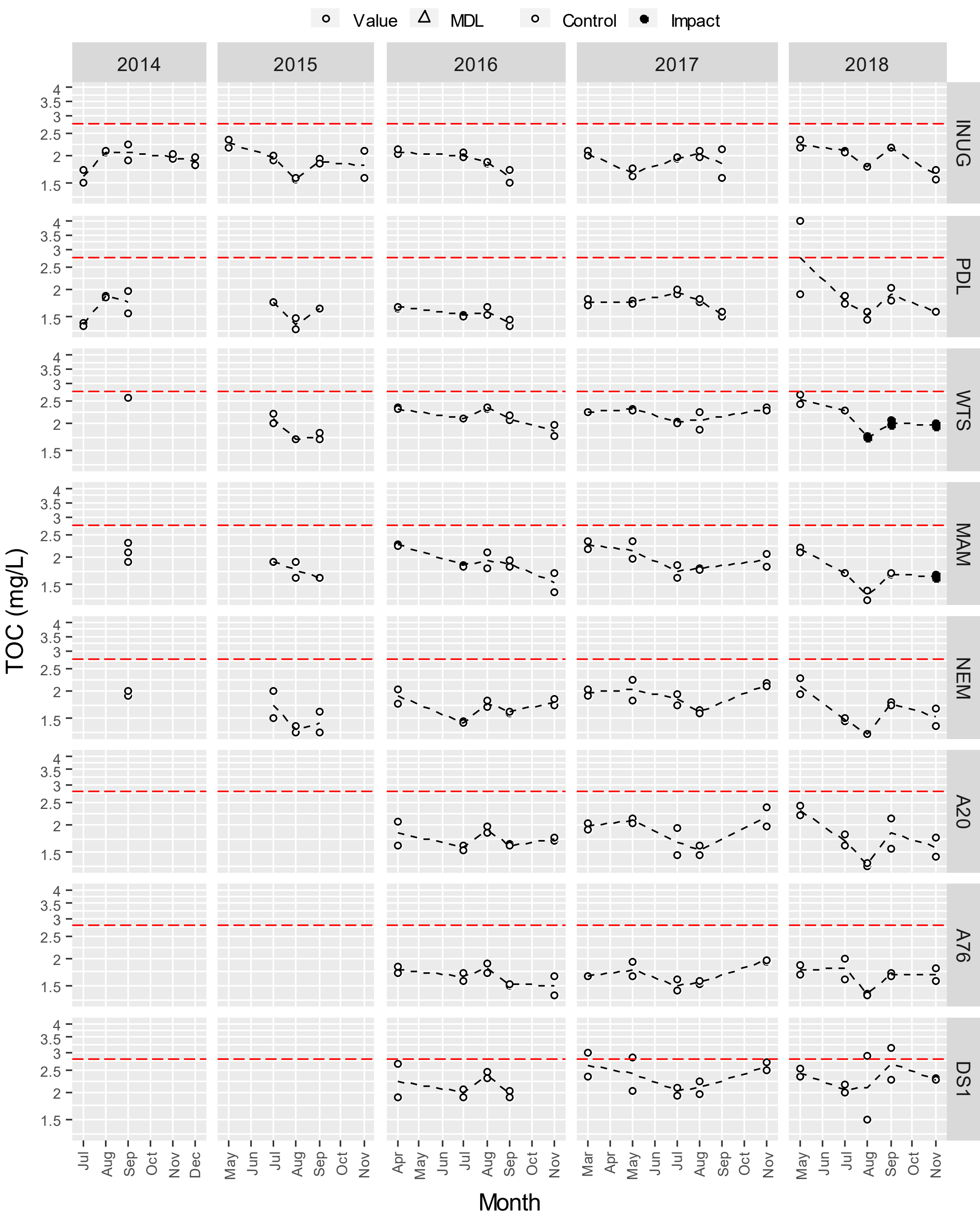


Figure 5-22. Total aluminum (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

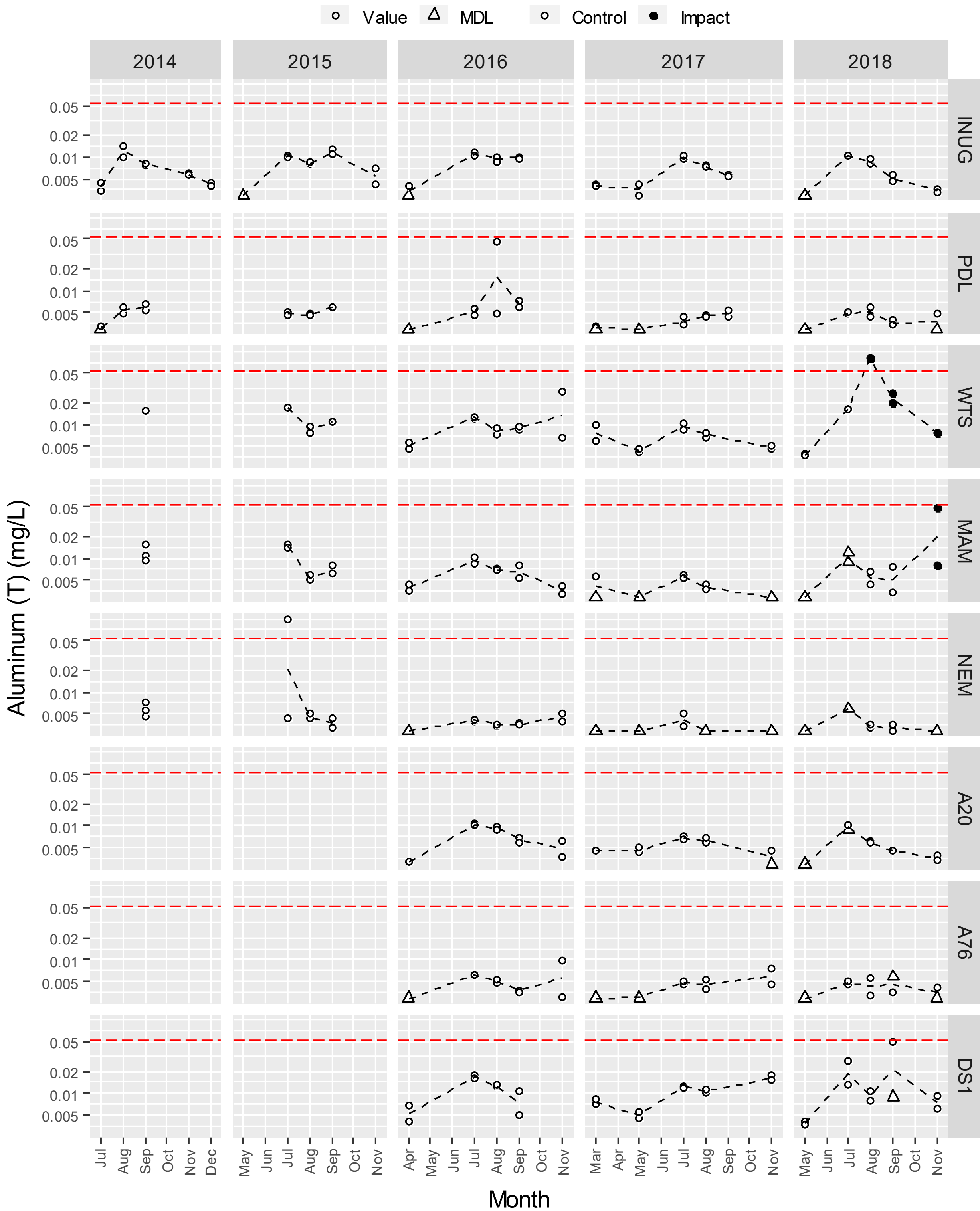


Figure 5-23. Total arsenic (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

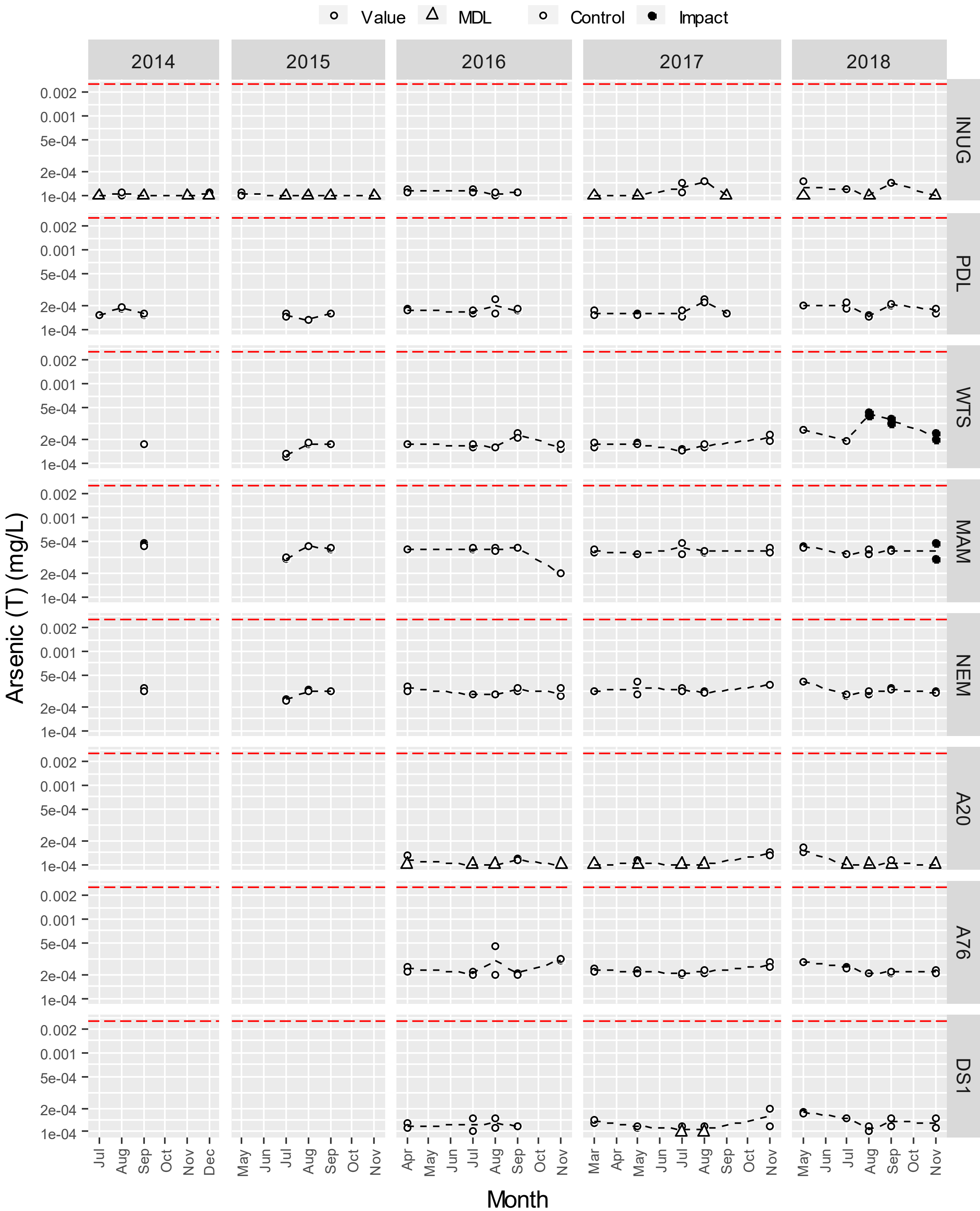


Figure 5-24. Total copper (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

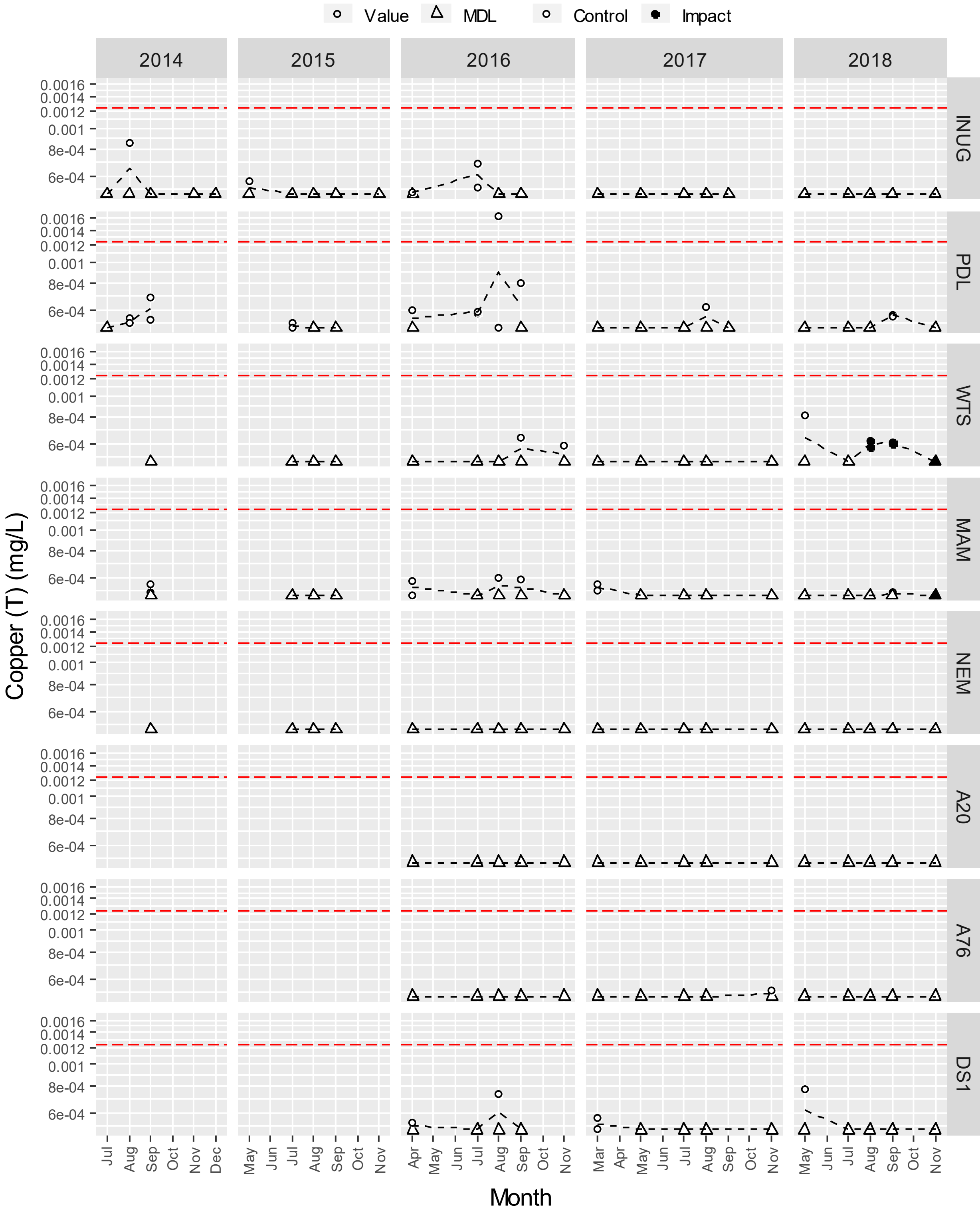


Figure 5-25. Total chromium (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

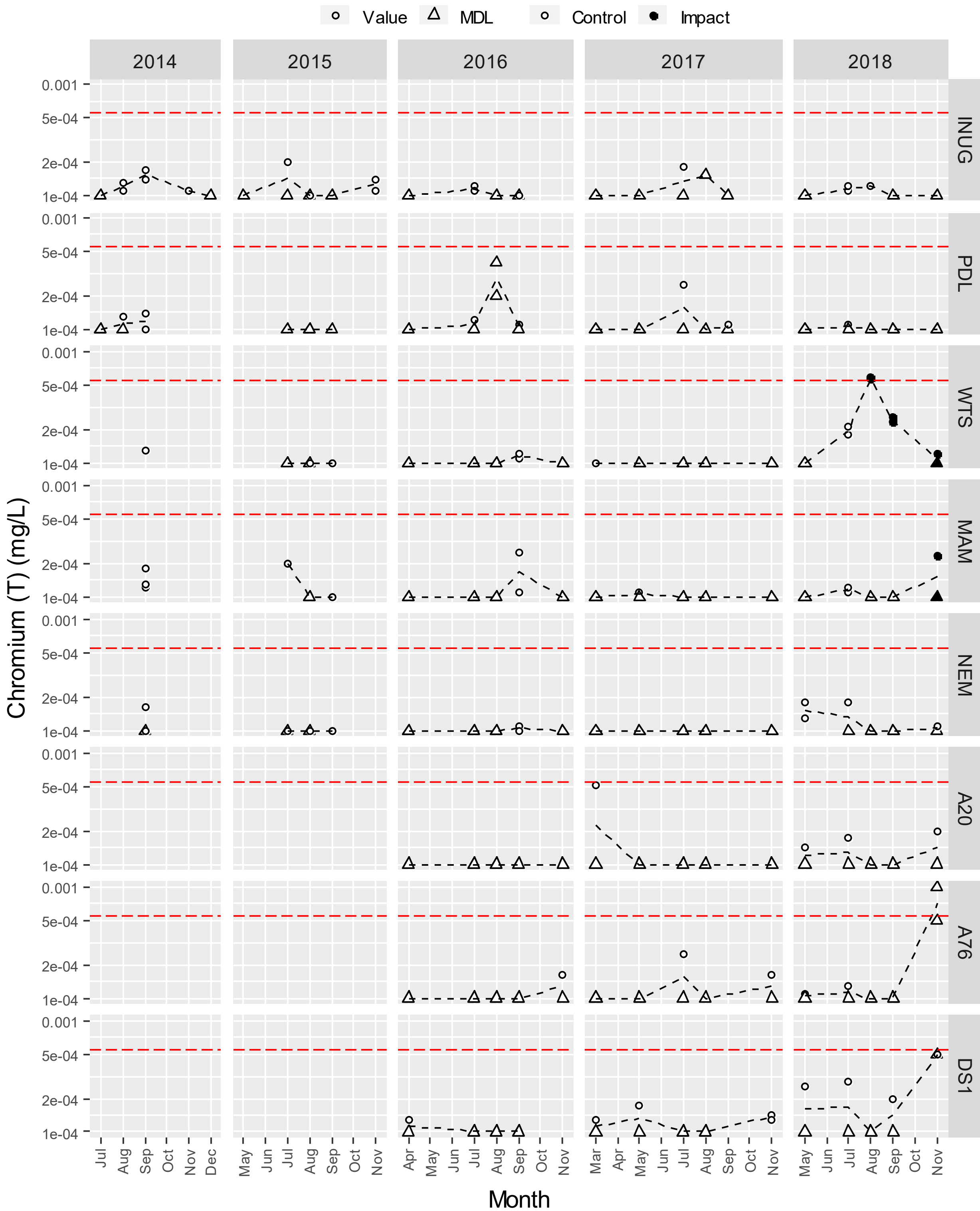


Figure 5-26. Total iron (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

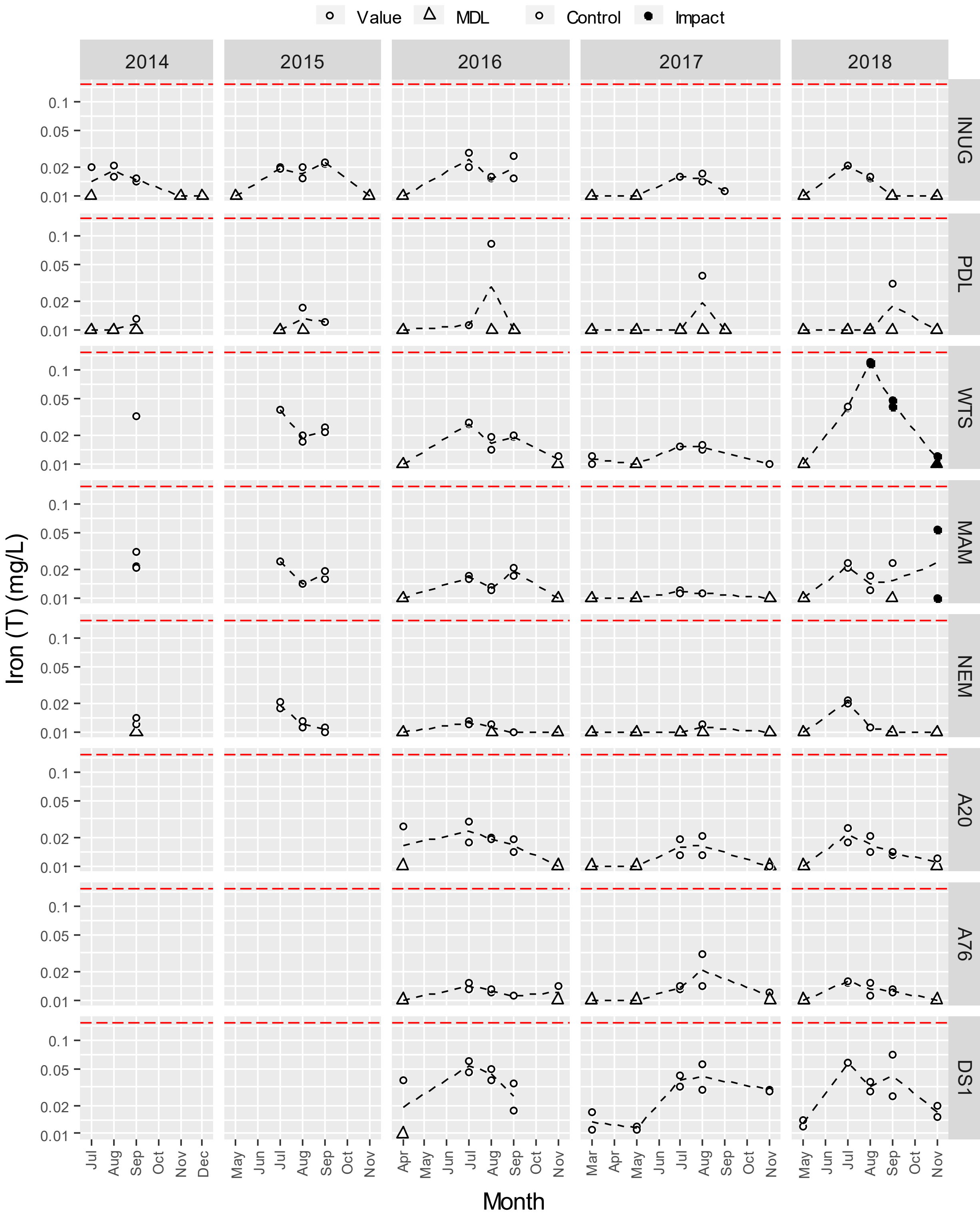


Figure 5-27. Total lead (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

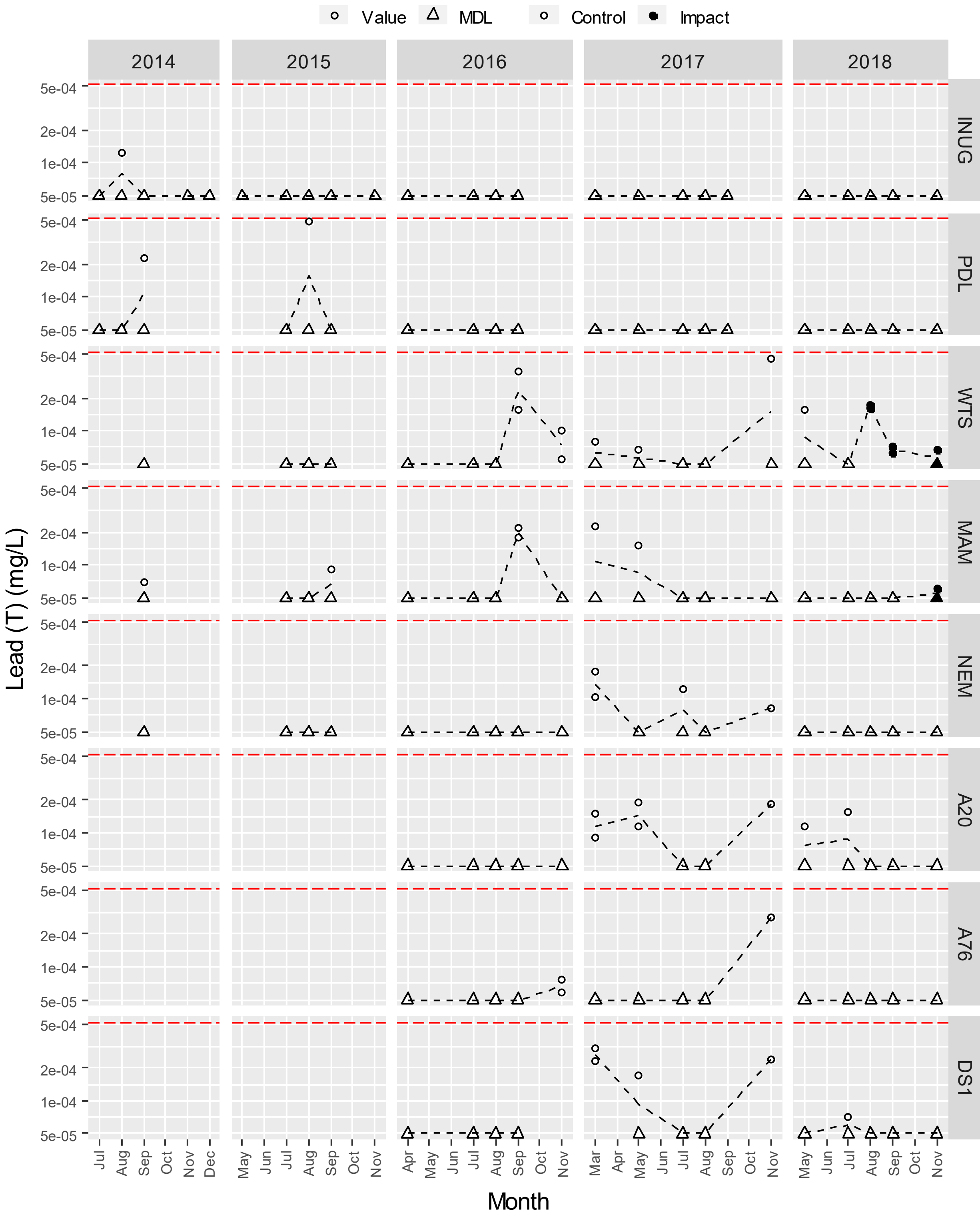


Figure 5-28. Total molybdenum (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

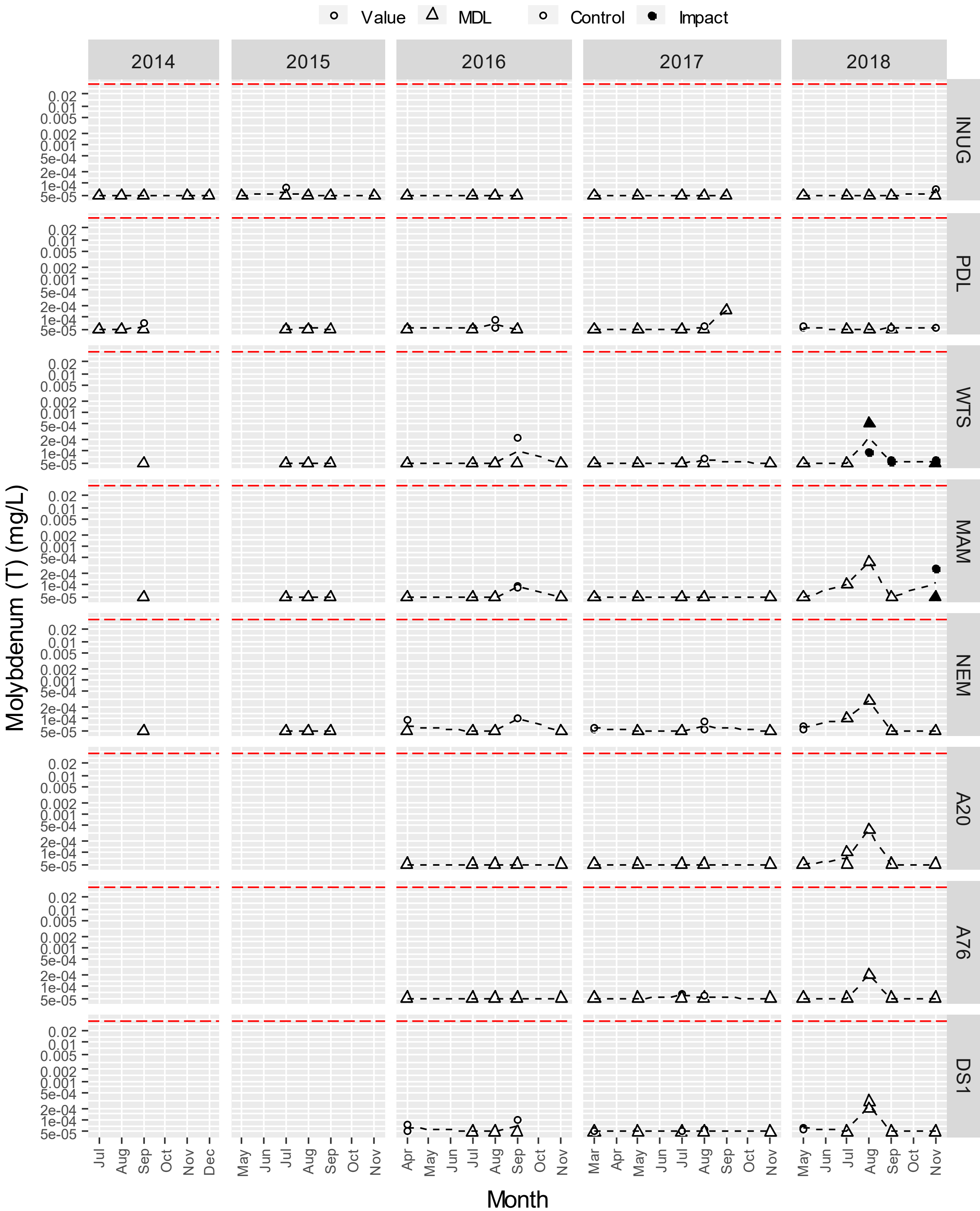


Figure 5-29. Total nickel (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

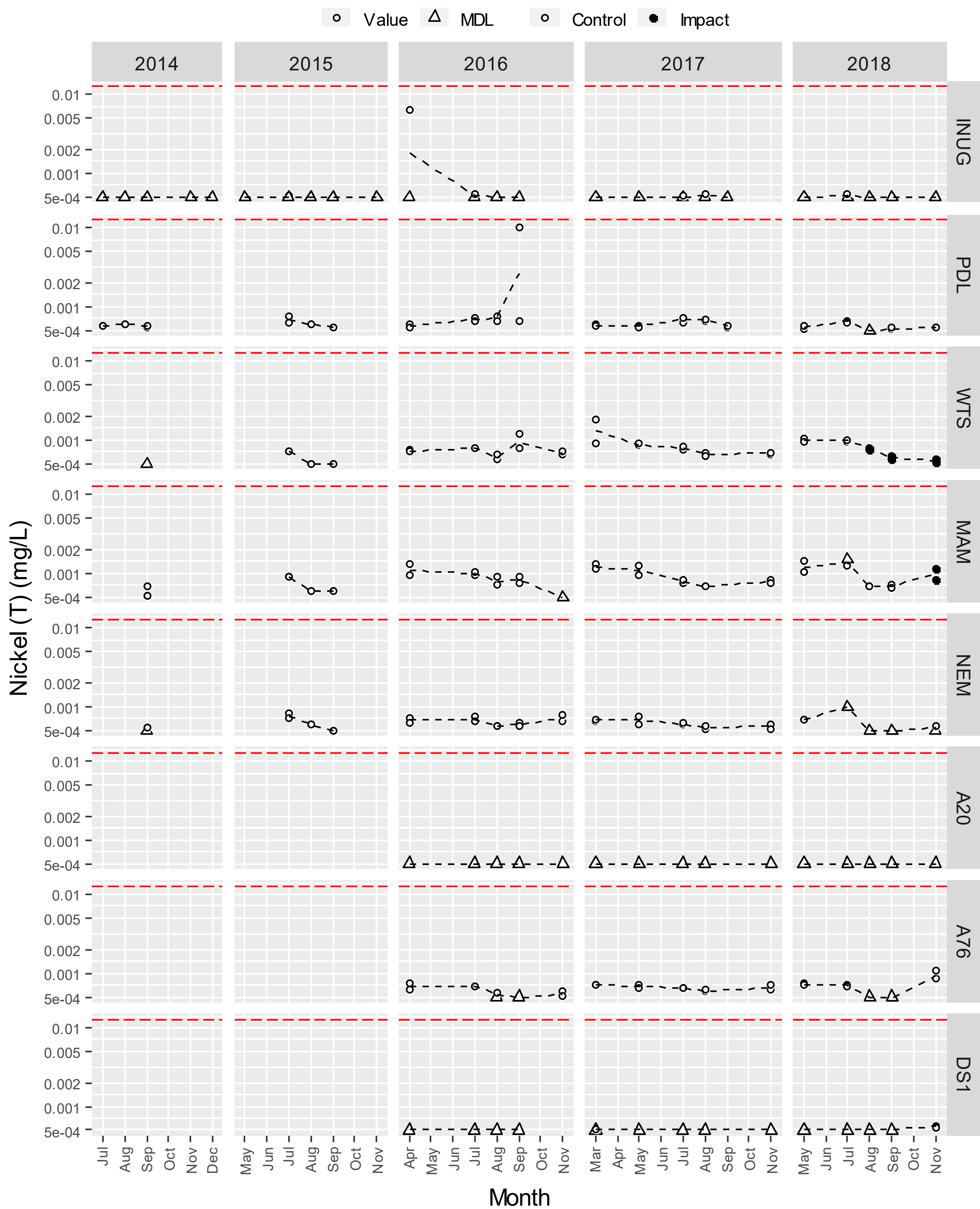


Figure 5-30. Dissolved aluminum (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

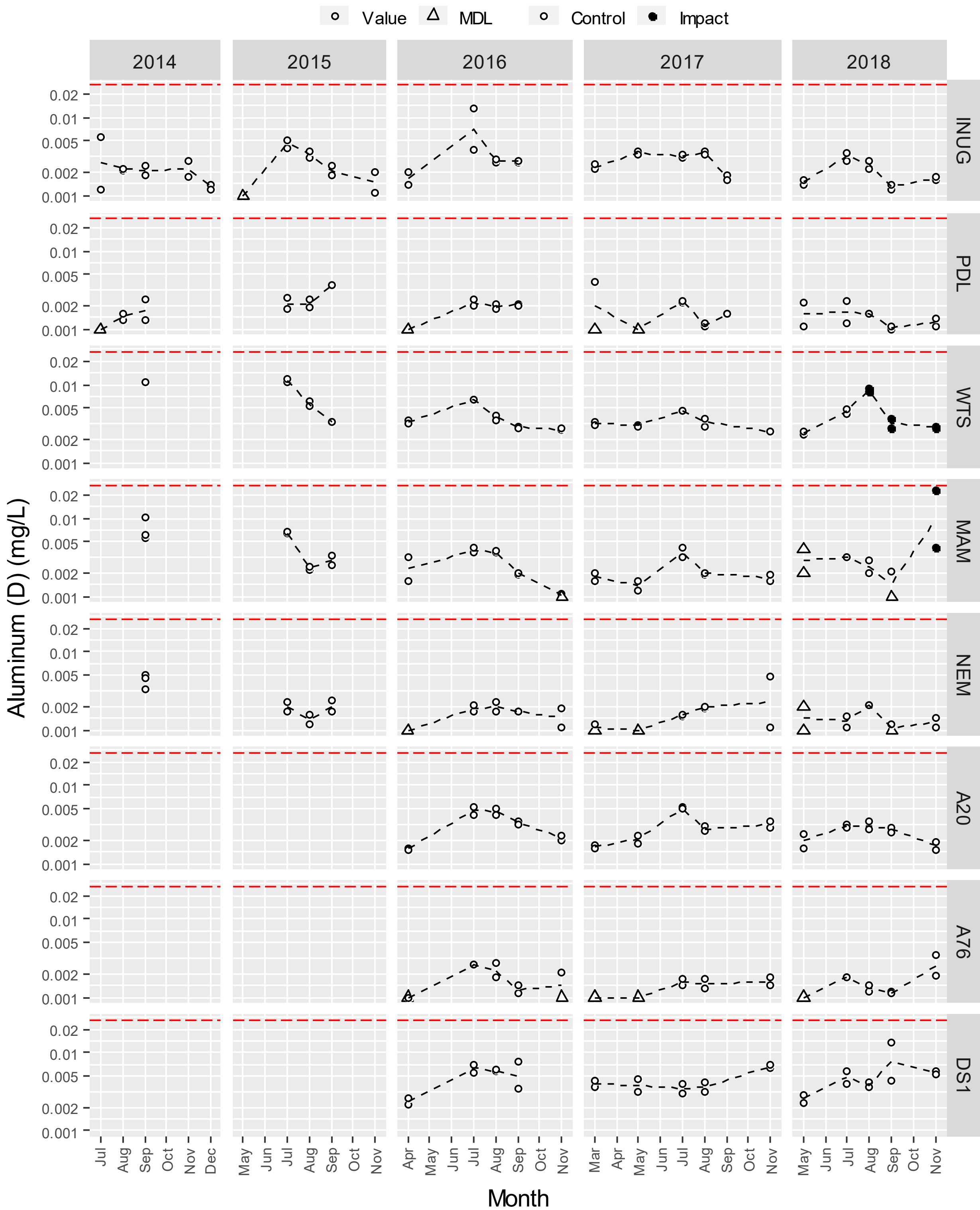


Figure 5-31. Dissolved arsenic (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

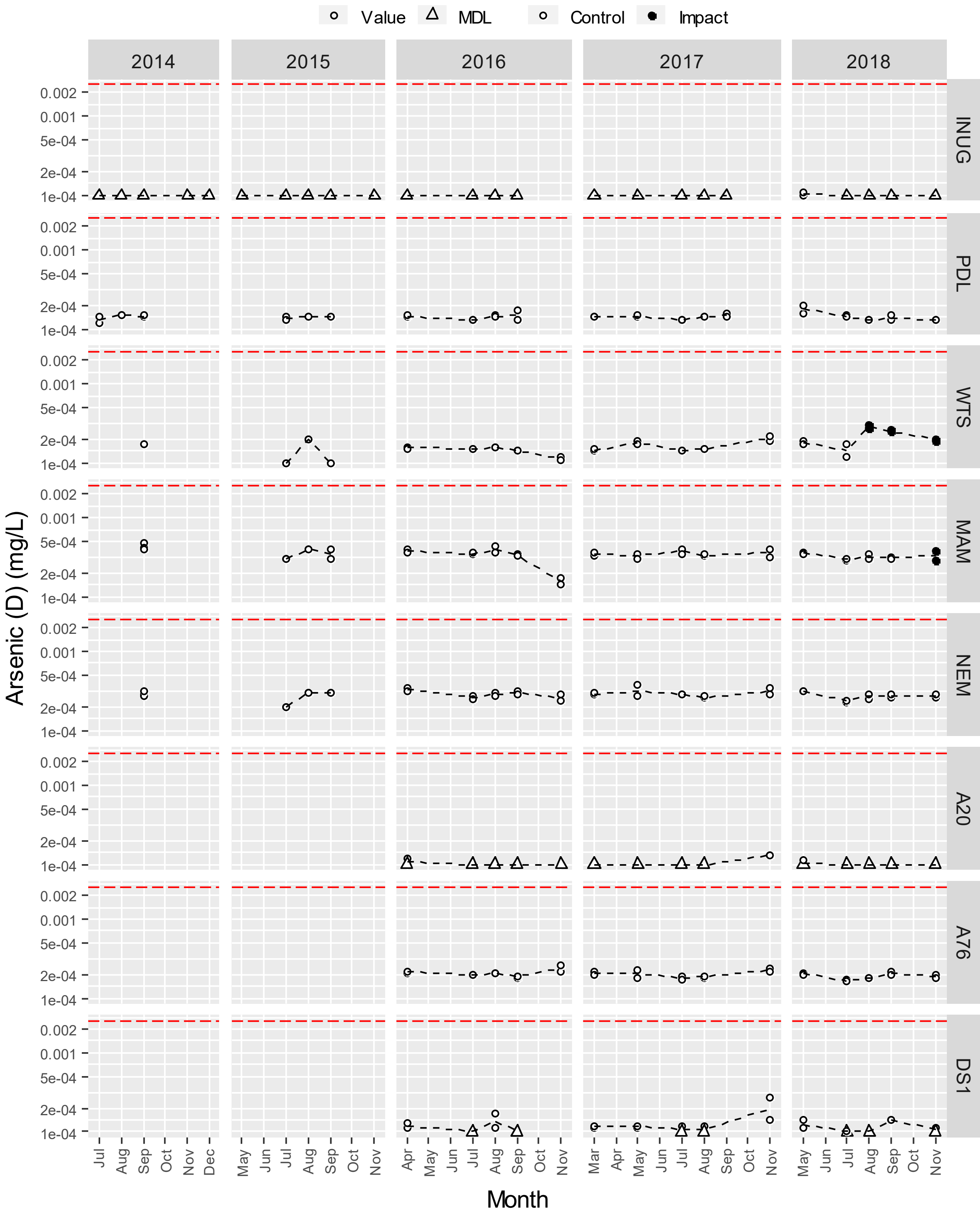


Figure 5-32. Dissolved chromium (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

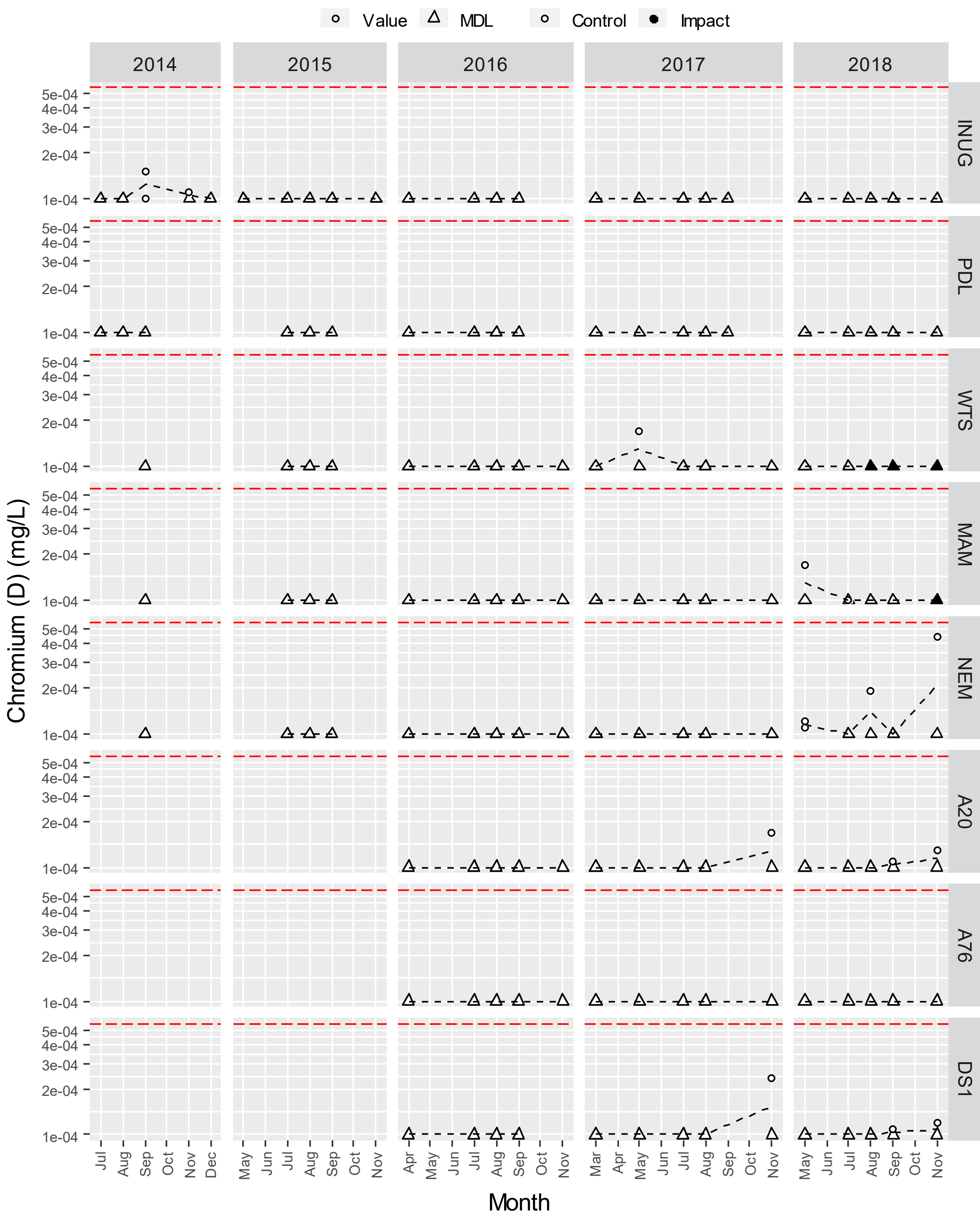


Figure 5-33. Dissolved copper (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

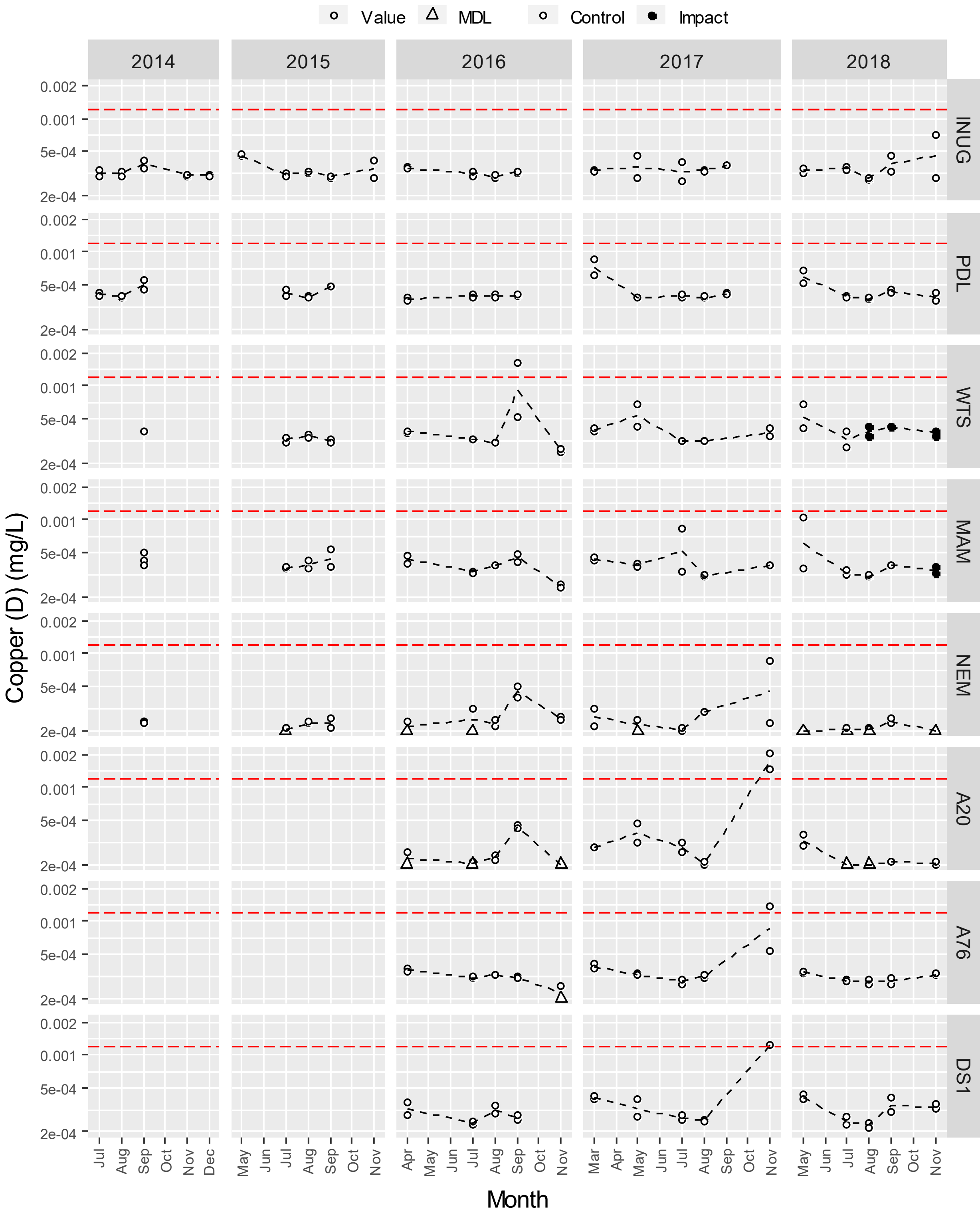


Figure 5-34. Dissolved iron (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

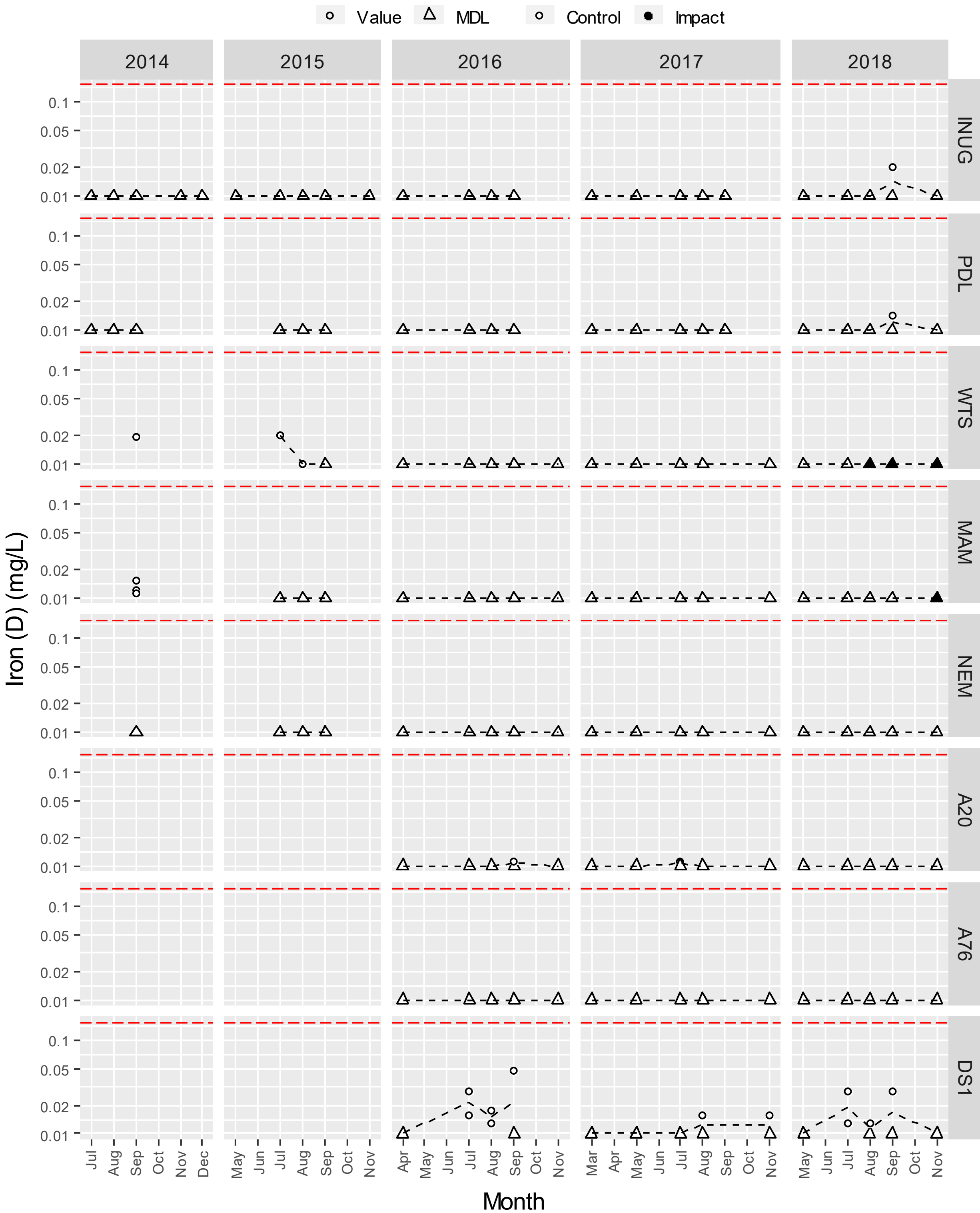


Figure 5-35. Dissolved lead (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

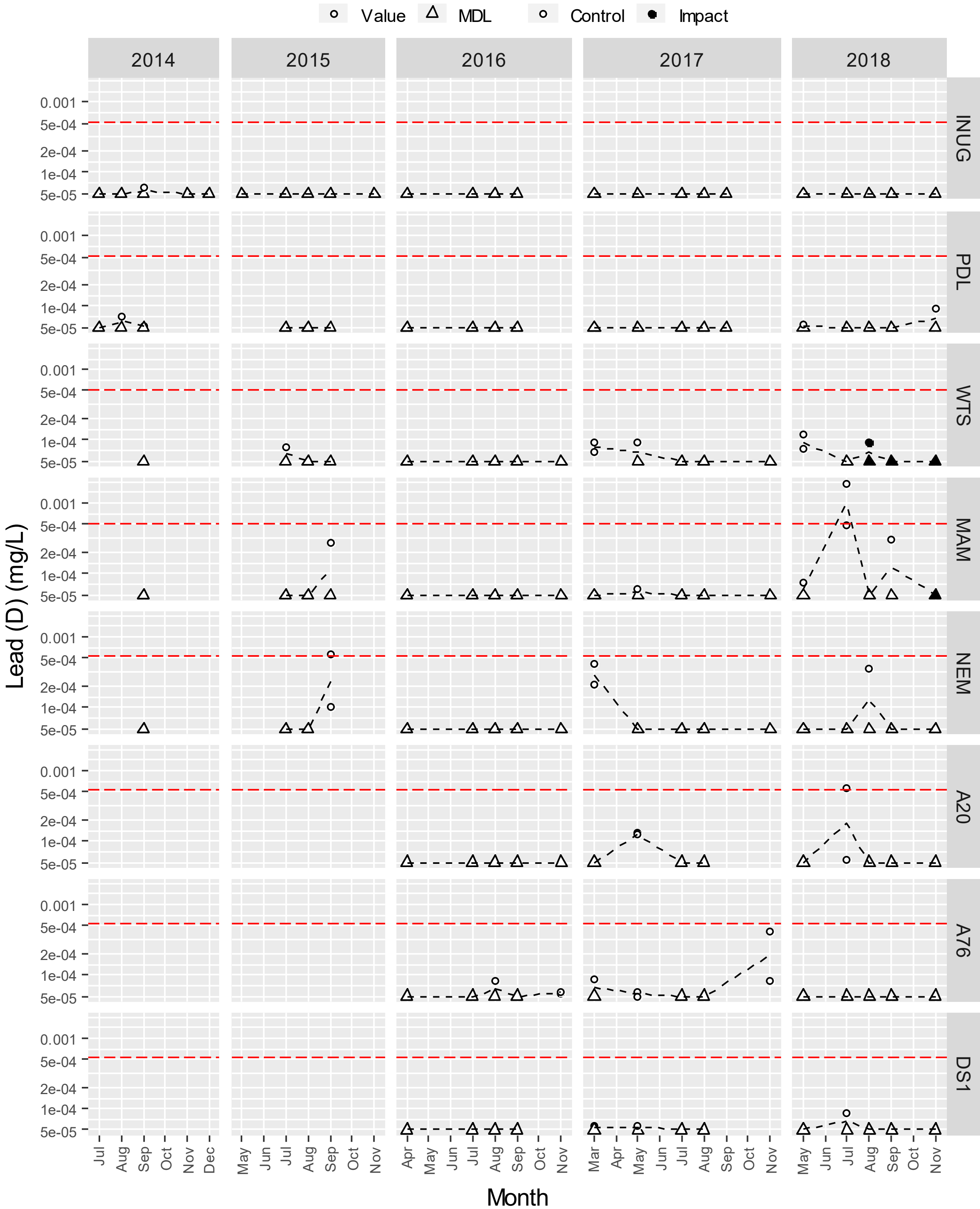


Figure 5-36. Dissolved molybdenum (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.

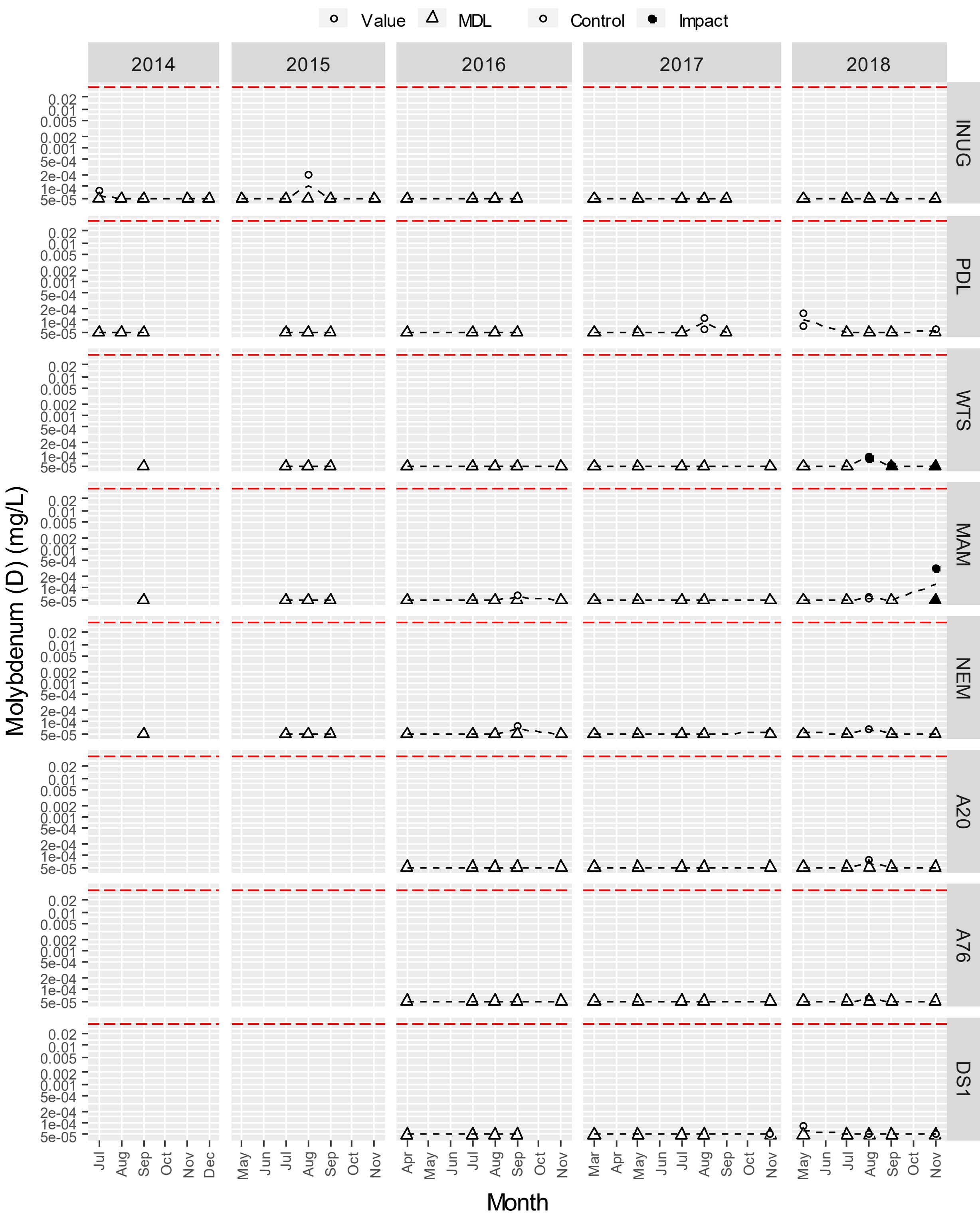
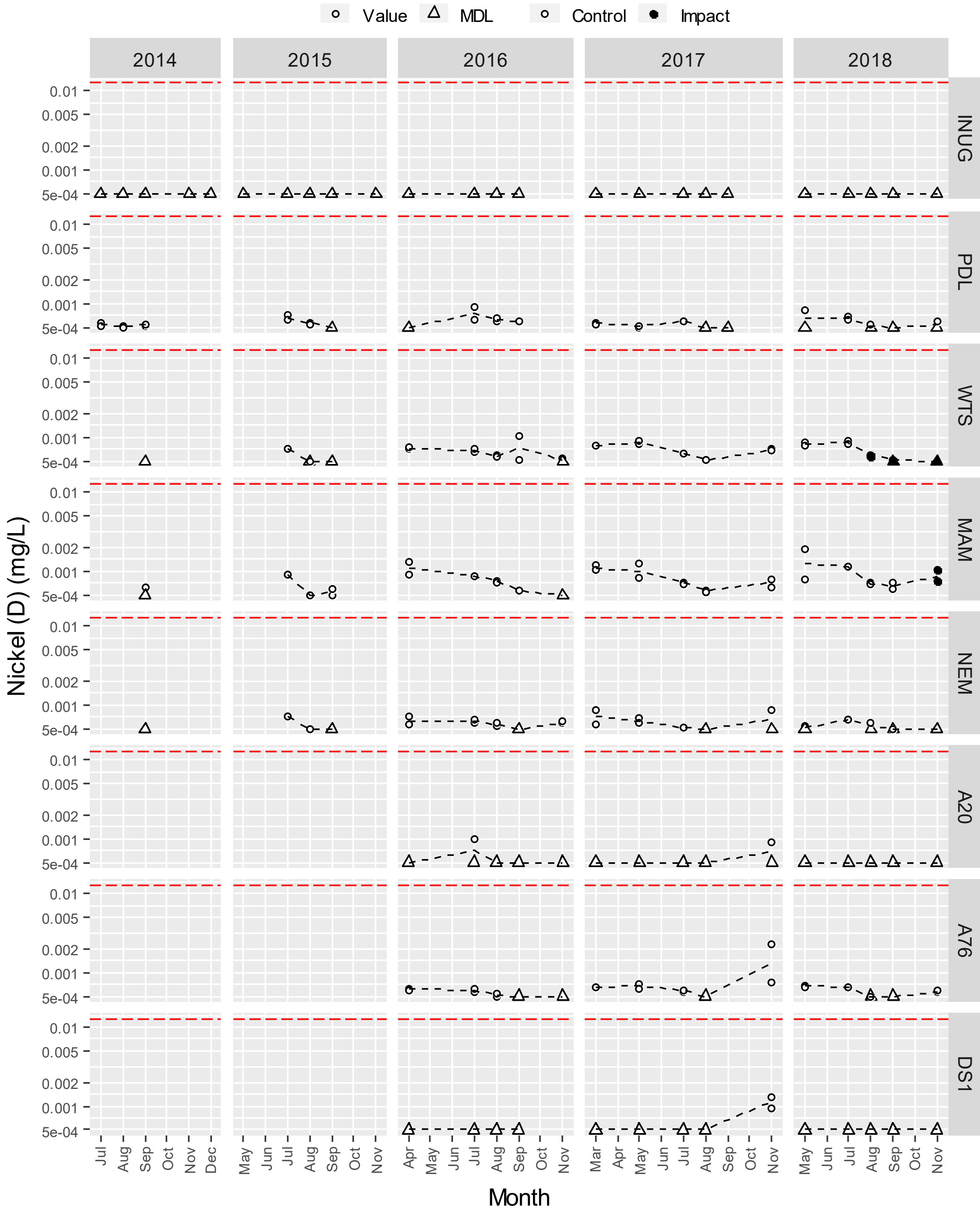


Figure 5-37. Dissolved nickel (mg/L) in water samples from Whale Tail study area lakes since 2014.

Note: Meadowbank trigger (red dashed line) shown for context.



Phytoplankton Tables and Figures

Figure 5-38. Chlorophyll-a (µg/L) in water samples from Whale Tail study area lakes since 2014.

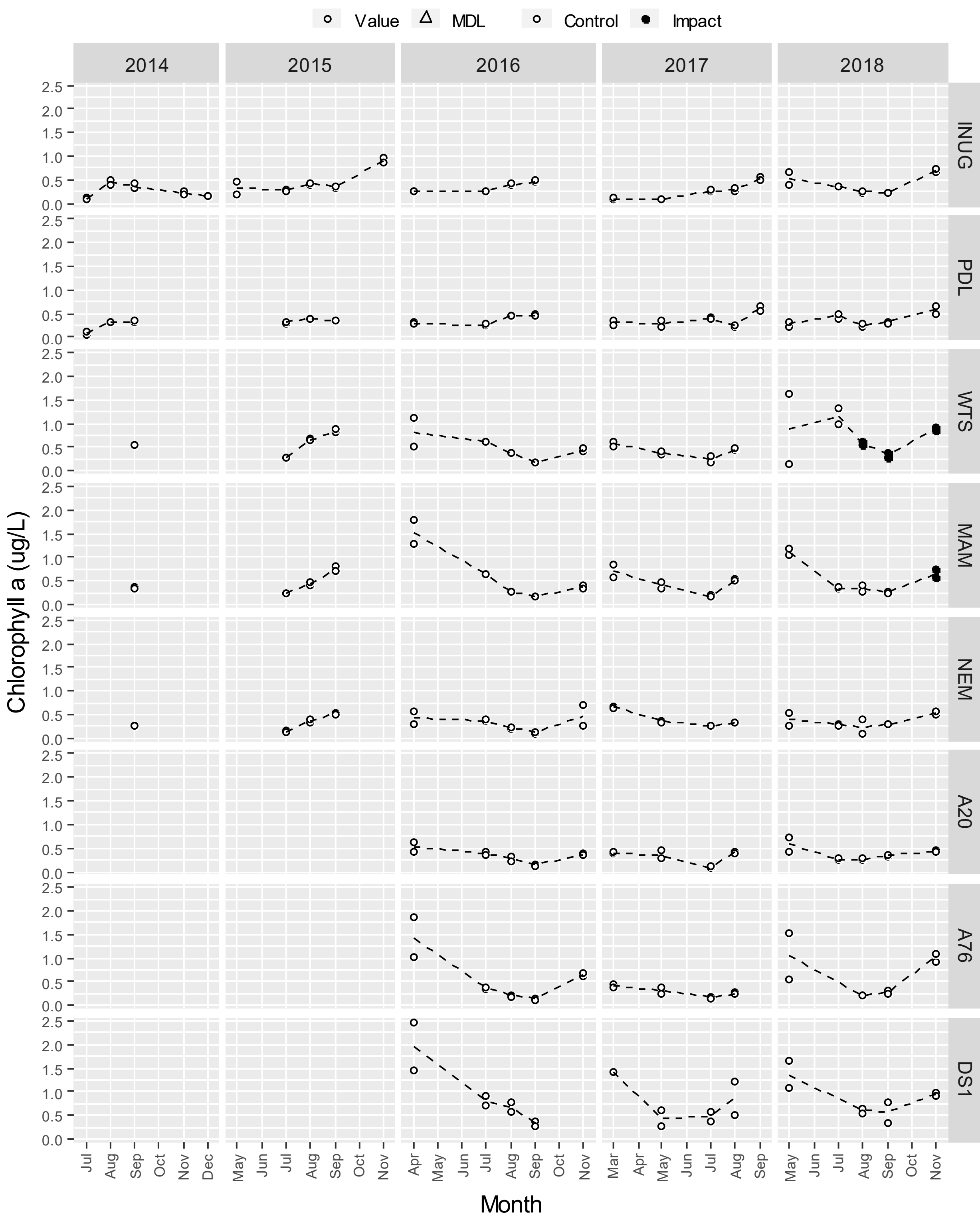


Figure 5-39. Total phytoplankton biomass (mg/m^3) from Whale Tail study area lakes since 2015.

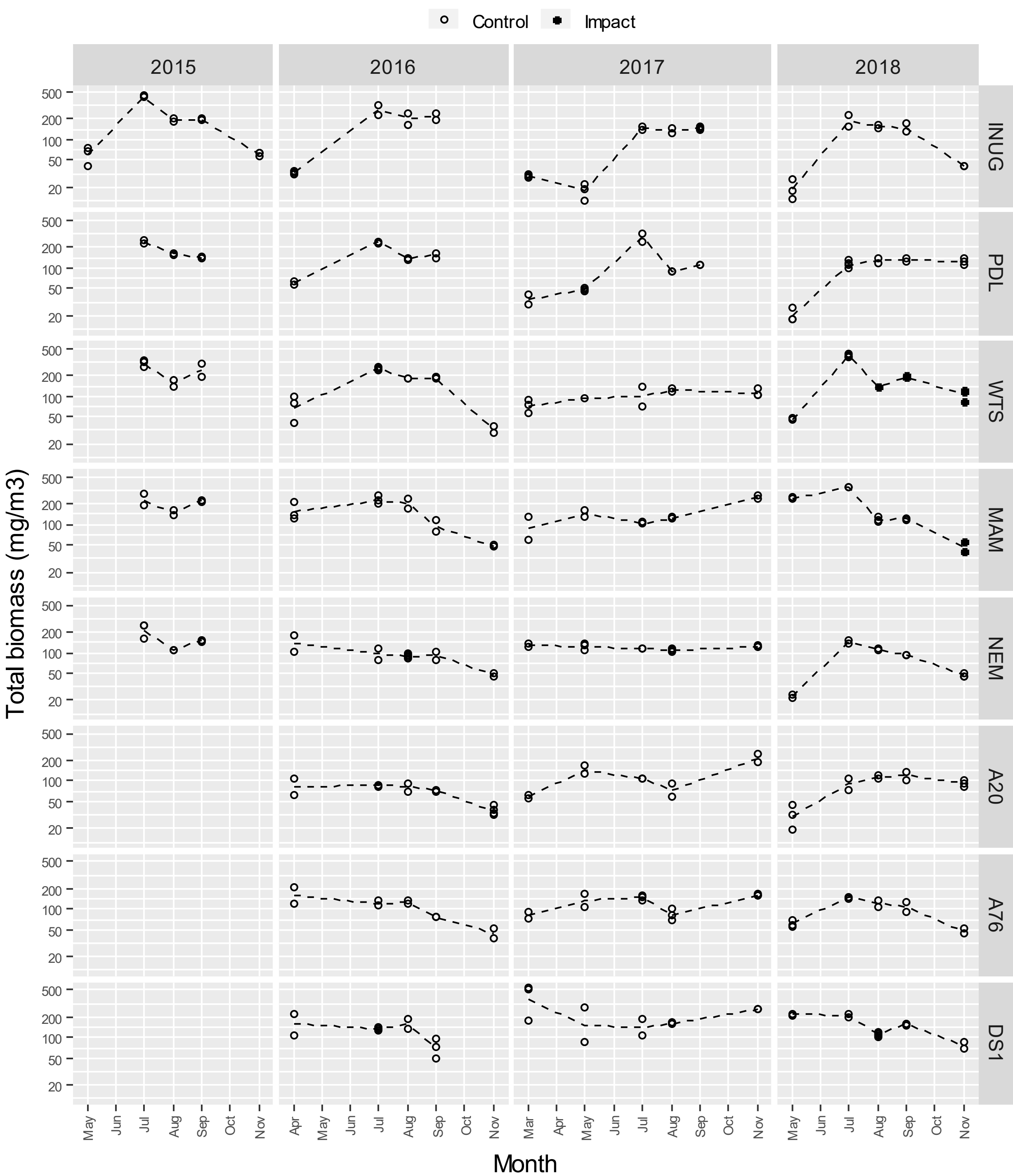


Figure 5-40. Phytoplankton biomass (mg/m^3) by major taxa group from Whale Tail study area lakes since 2015.

Figure 5-41. Relative phytoplankton biomass by major taxa group from Whale Tail study area lakes since 2015.

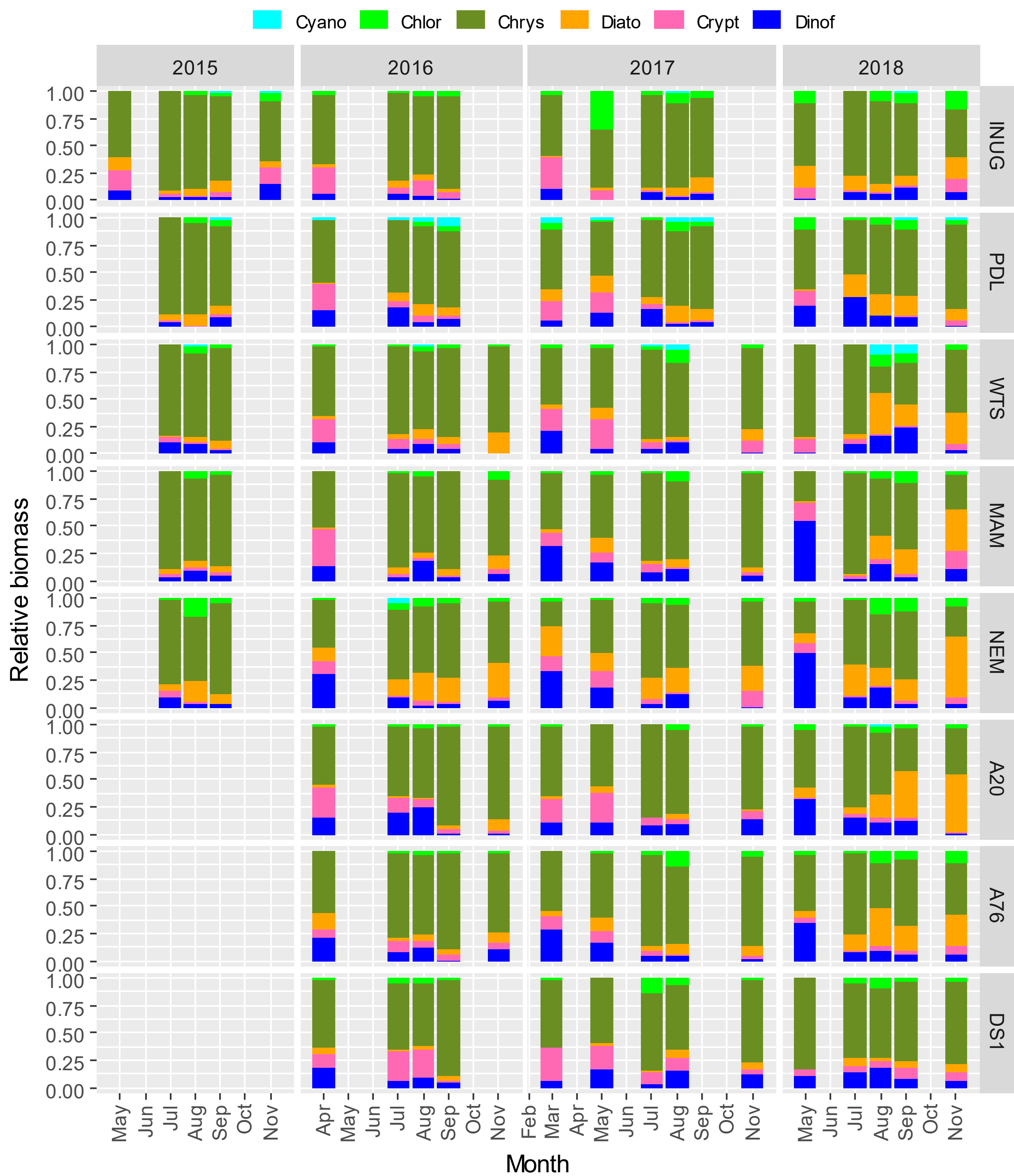
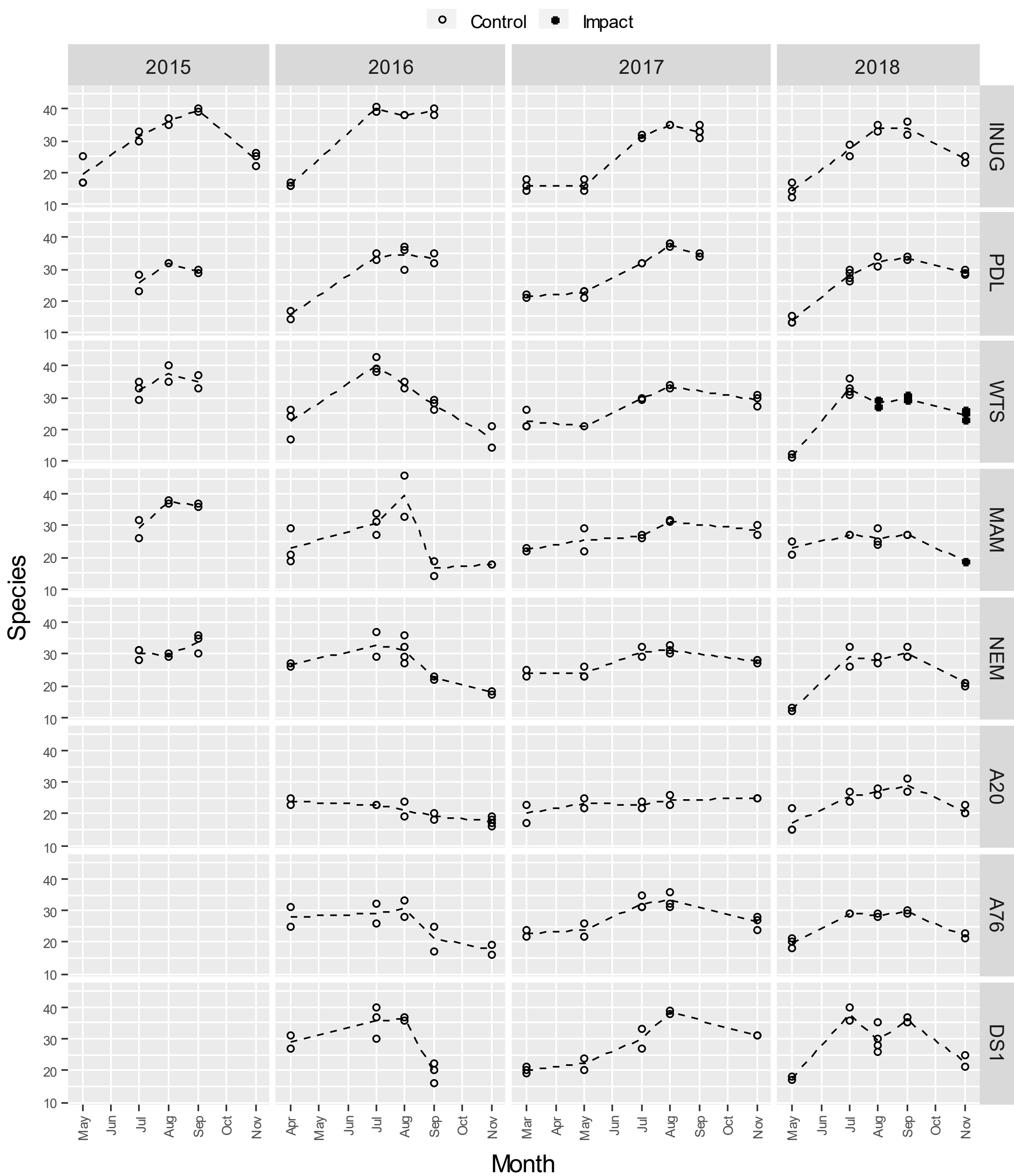


Figure 5-42. Phytoplankton species richness from Whale Tail study area lakes since 2015.



Sediment Chemistry Tables and Figures

Figure 5-43. Sediment grain size composition in sediment from the Whale Tail study area lakes.

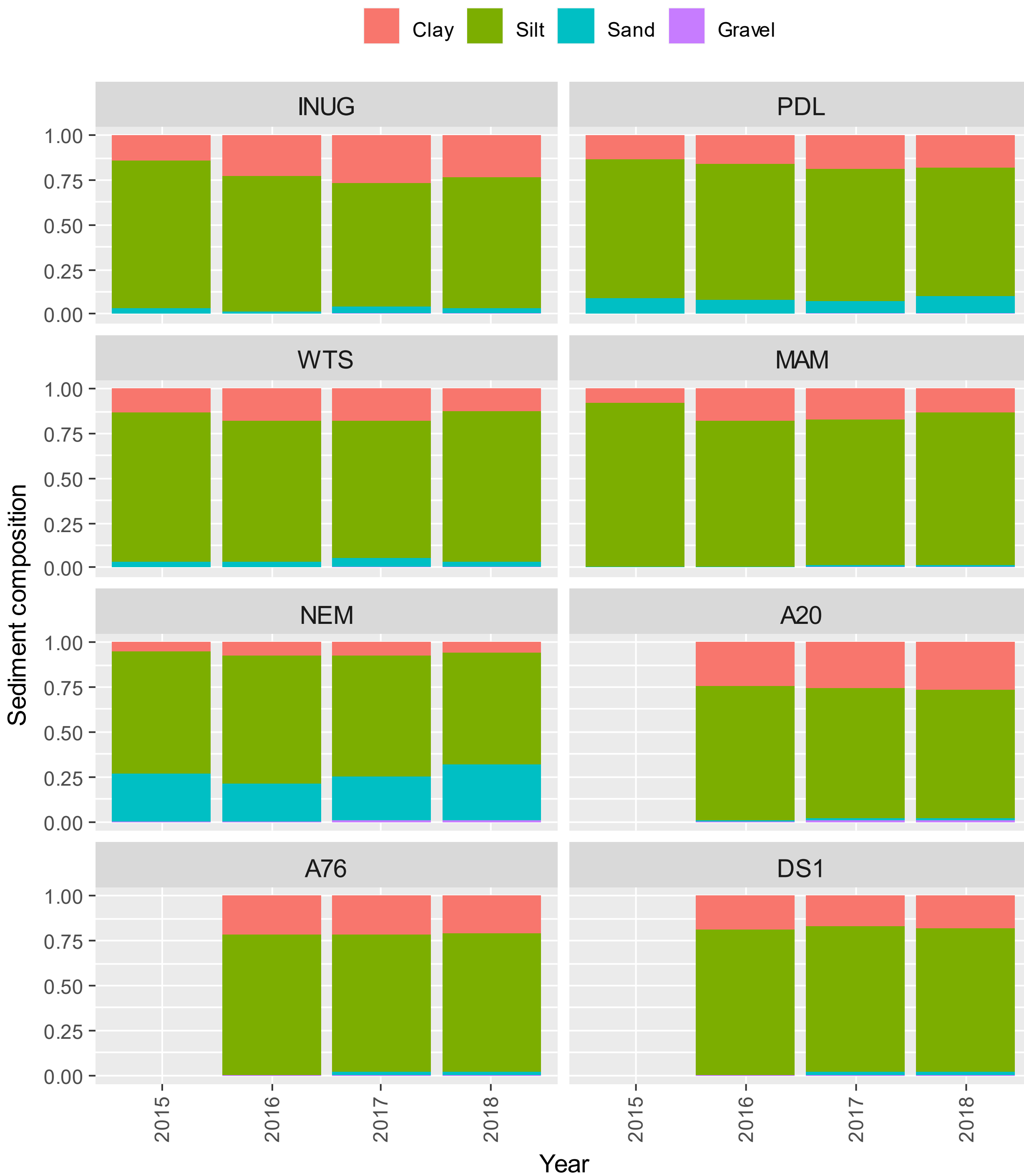


Figure 5-44. Arsenic (mg/kg dw) in sediment samples (grabs & cores) from Whale Tail study area lakes since 2015.

Note: The red dashed line represents the trigger value for the Meadowbank study area lakes.

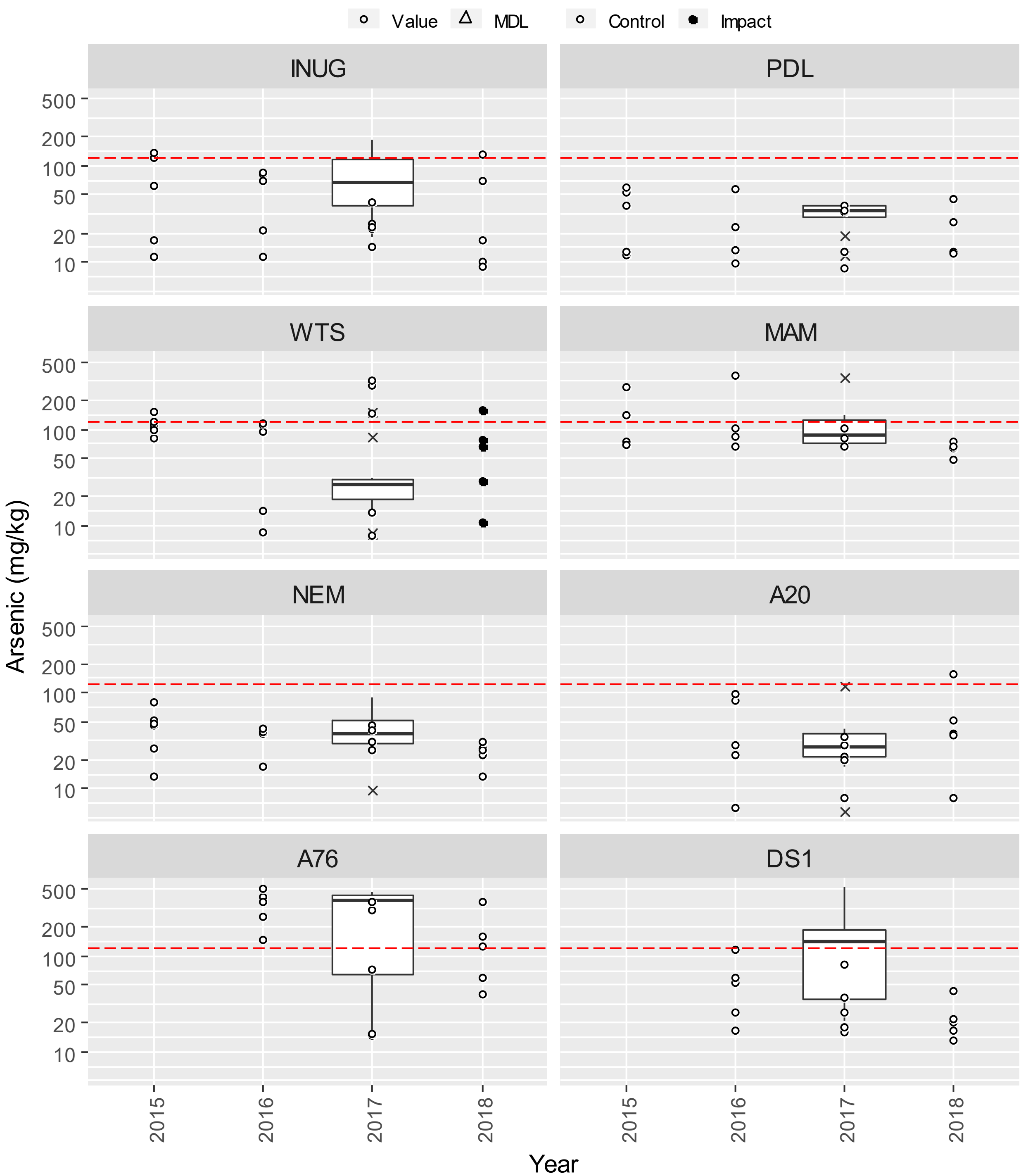


Figure 5-45. Cadmium (mg/kg) in sediment samples (grabs & cores) from Whale Tail study area lakes since 2015.

Note: The red dashed line represents the trigger value for the Meadowbank study area lakes.

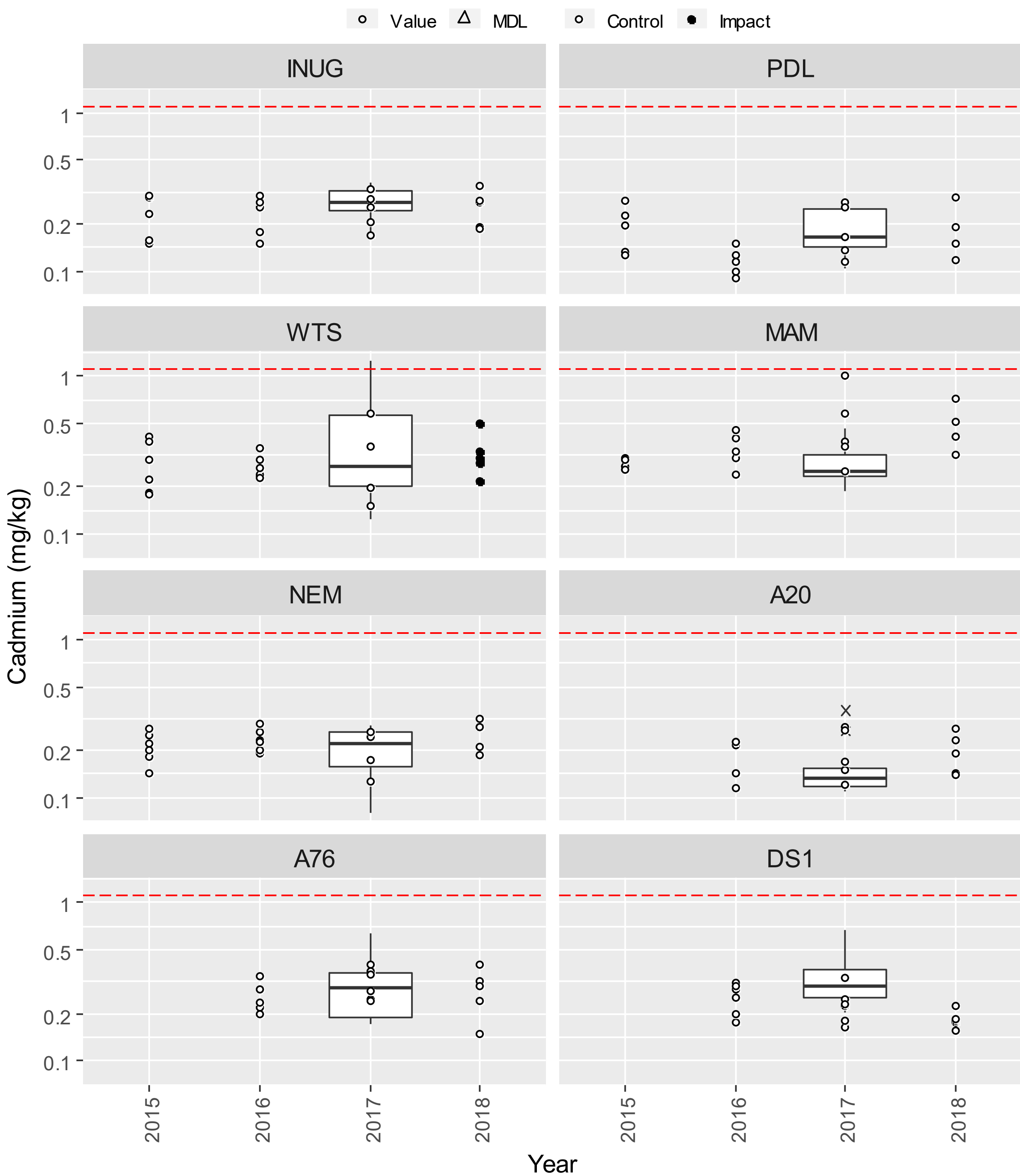


Figure 5-46. Chromium (mg/kg dw) in sediment samples (grabs & cores) from Whale Tail study area lakes since 2015.

Note: The red dashed line represents the trigger value for the Meadowbank study area lakes.

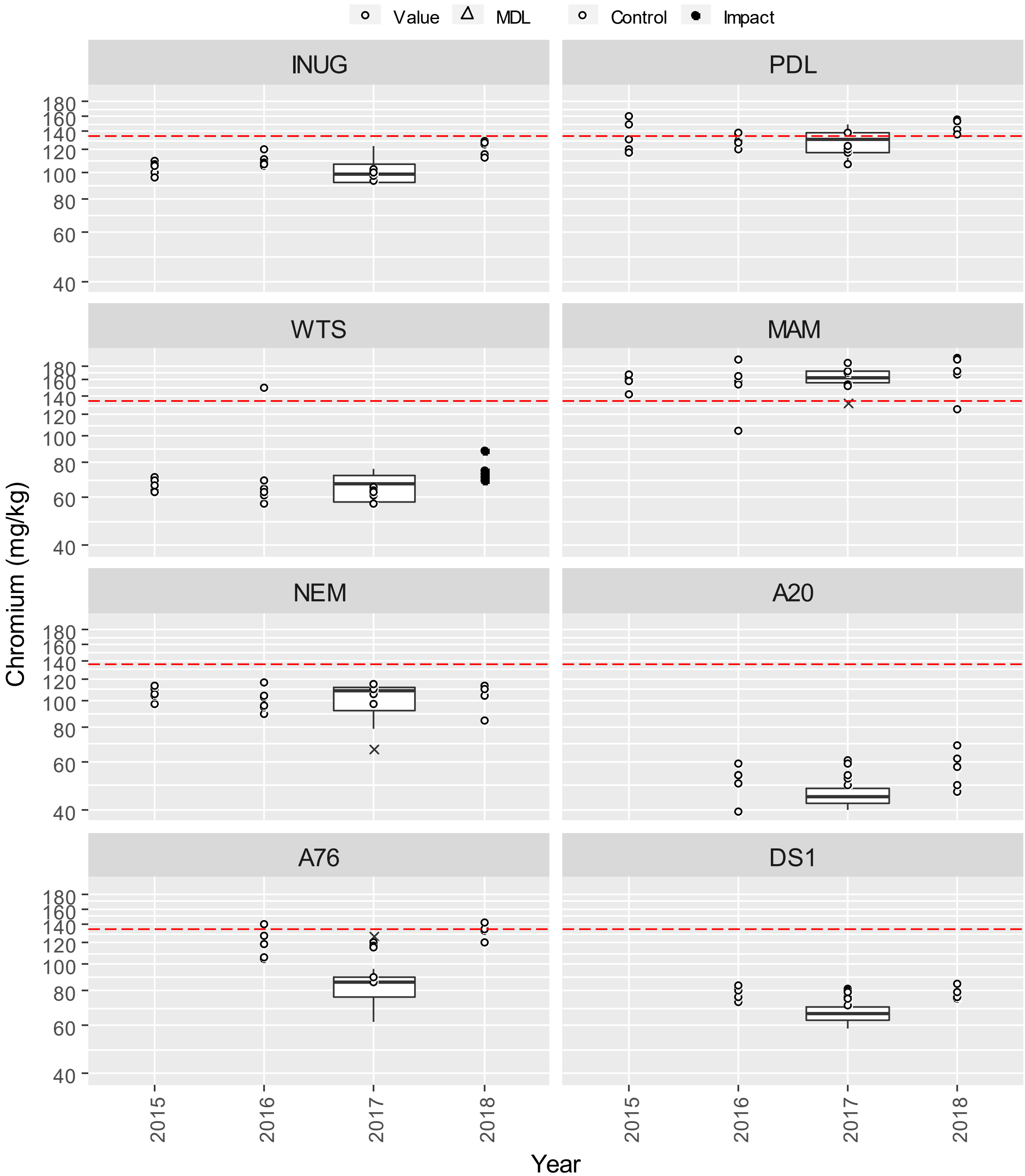


Figure 5-47. Copper (mg/kg dw) in sediment samples (grabs & cores) from Whale Tail study area lakes since 2015.

Note: The red dashed line represents the trigger value for the Meadowbank study area lakes.

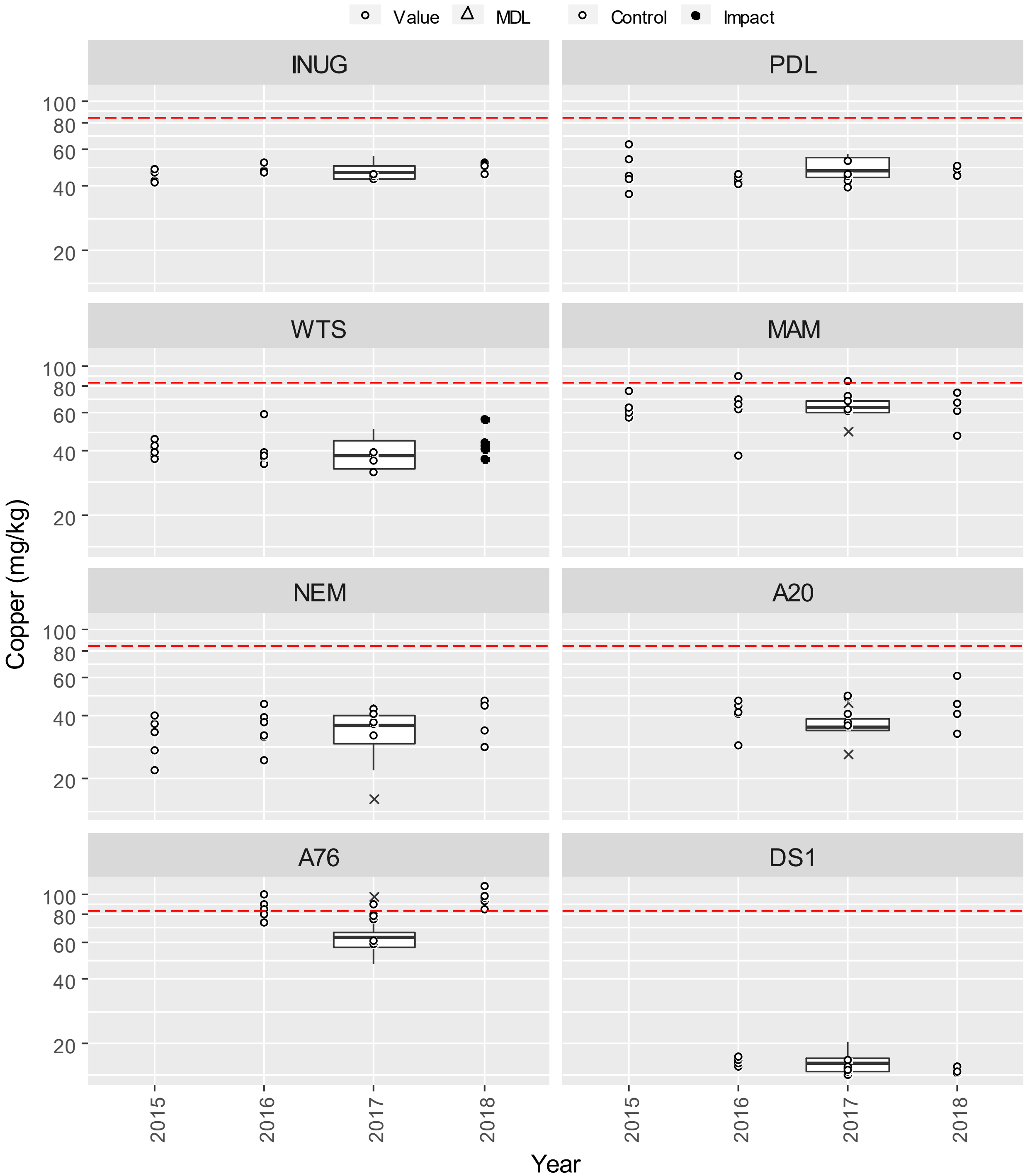


Figure 5-48. Lead (mg/kg dw) in sediment samples (grabs & cores) from Whale Tail study area lakes since 2015.

Note: The red dashed line represents the trigger value for the Meadowbank study area lakes.

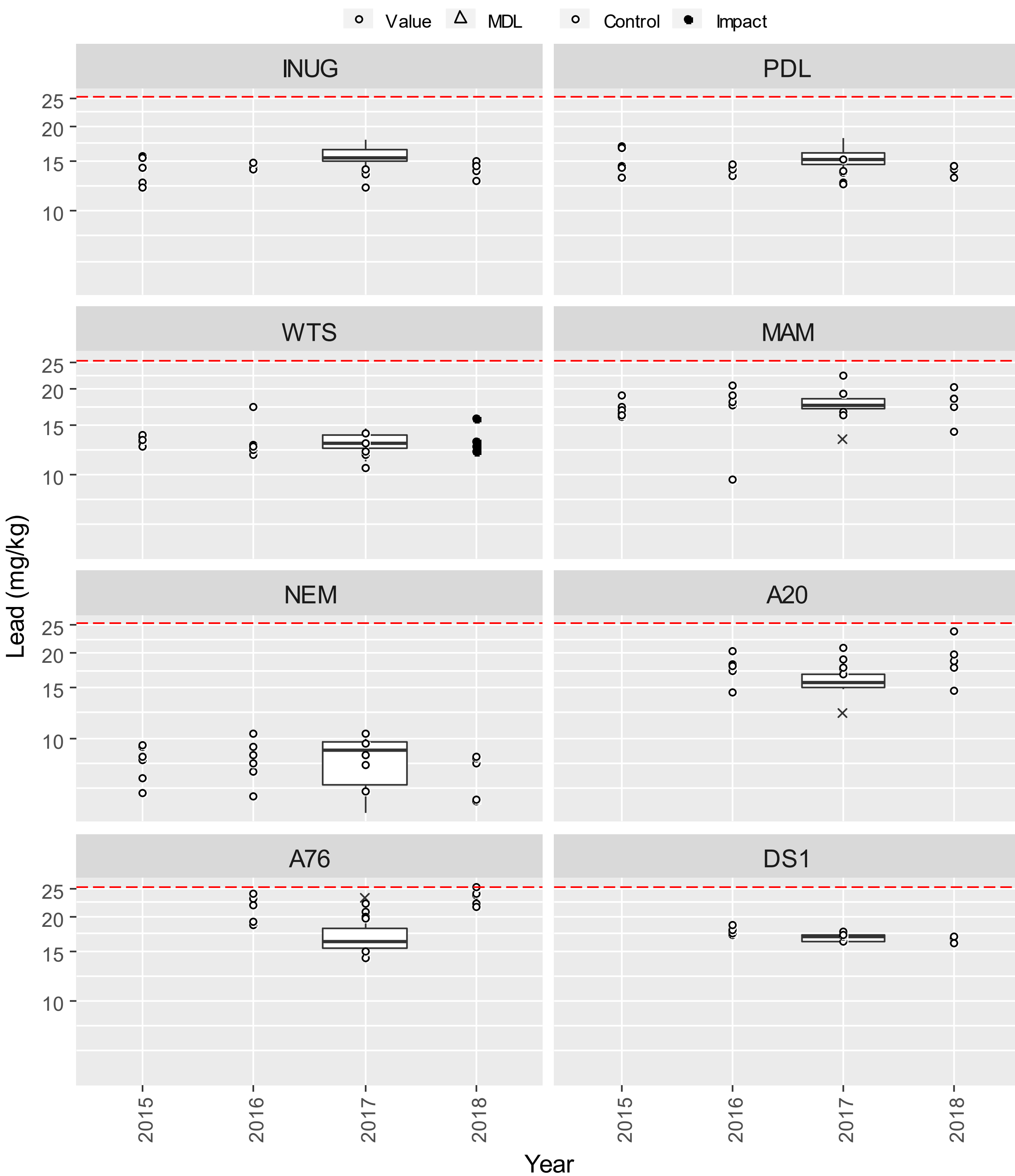


Figure 5-49. Mercury (mg/kg dw) in sediment samples (grabs & cores) from Whale Tail study area lakes since 2015.

Note: The red dashed line represents the trigger value for the Meadowbank study area lakes.

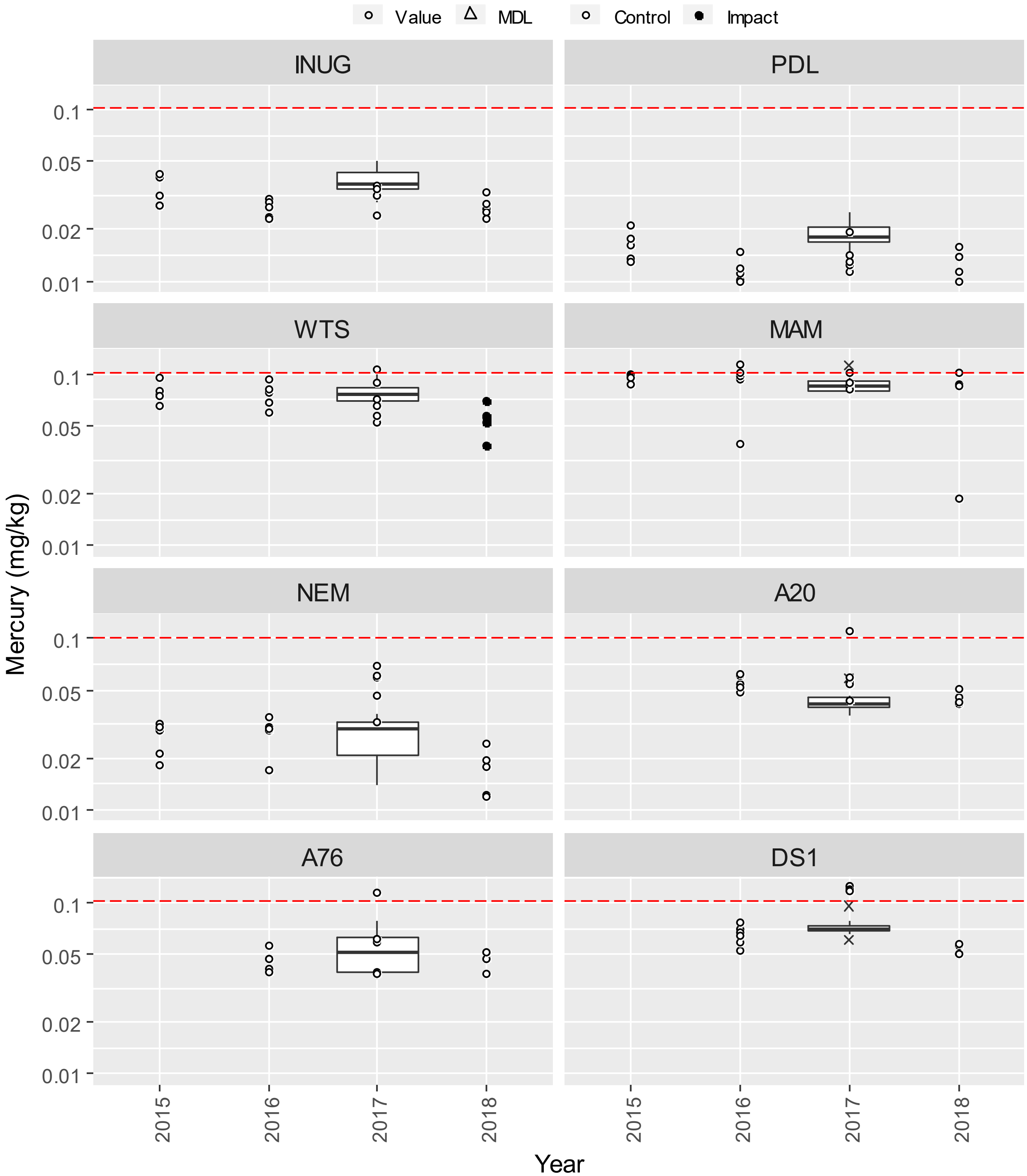
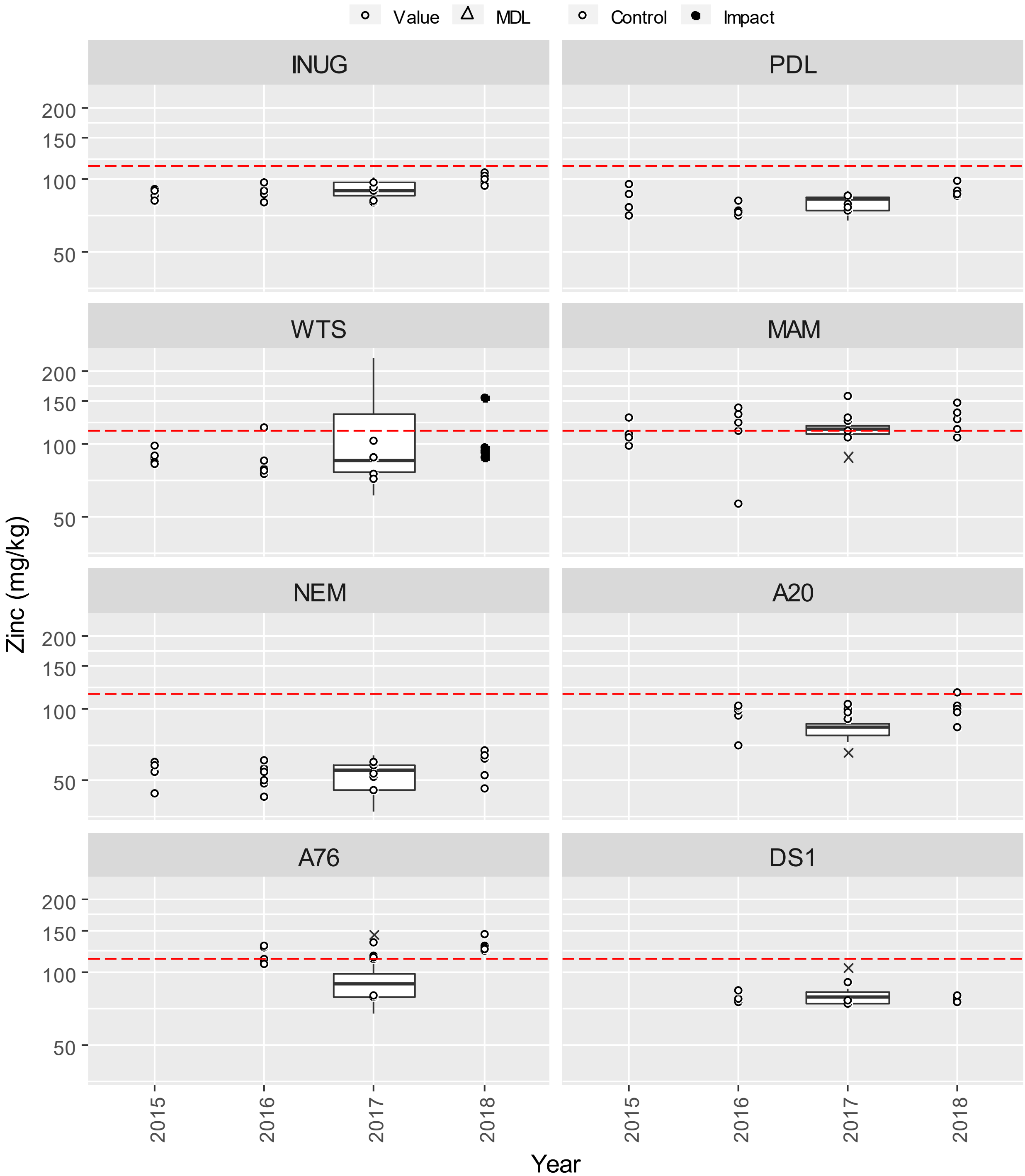


Figure 5-50. Zinc (mg/kg dw) in sediment samples (grabs & cores) from Whale Tail study area lakes since 2015.

Note: The red dashed line represents the trigger value for the Meadowbank study area lakes.



Benthos Tables and Figures

Figure 5-51. Benthic invertebrate total abundance (#/m^2) from Whale Tail study area lakes since 2015.

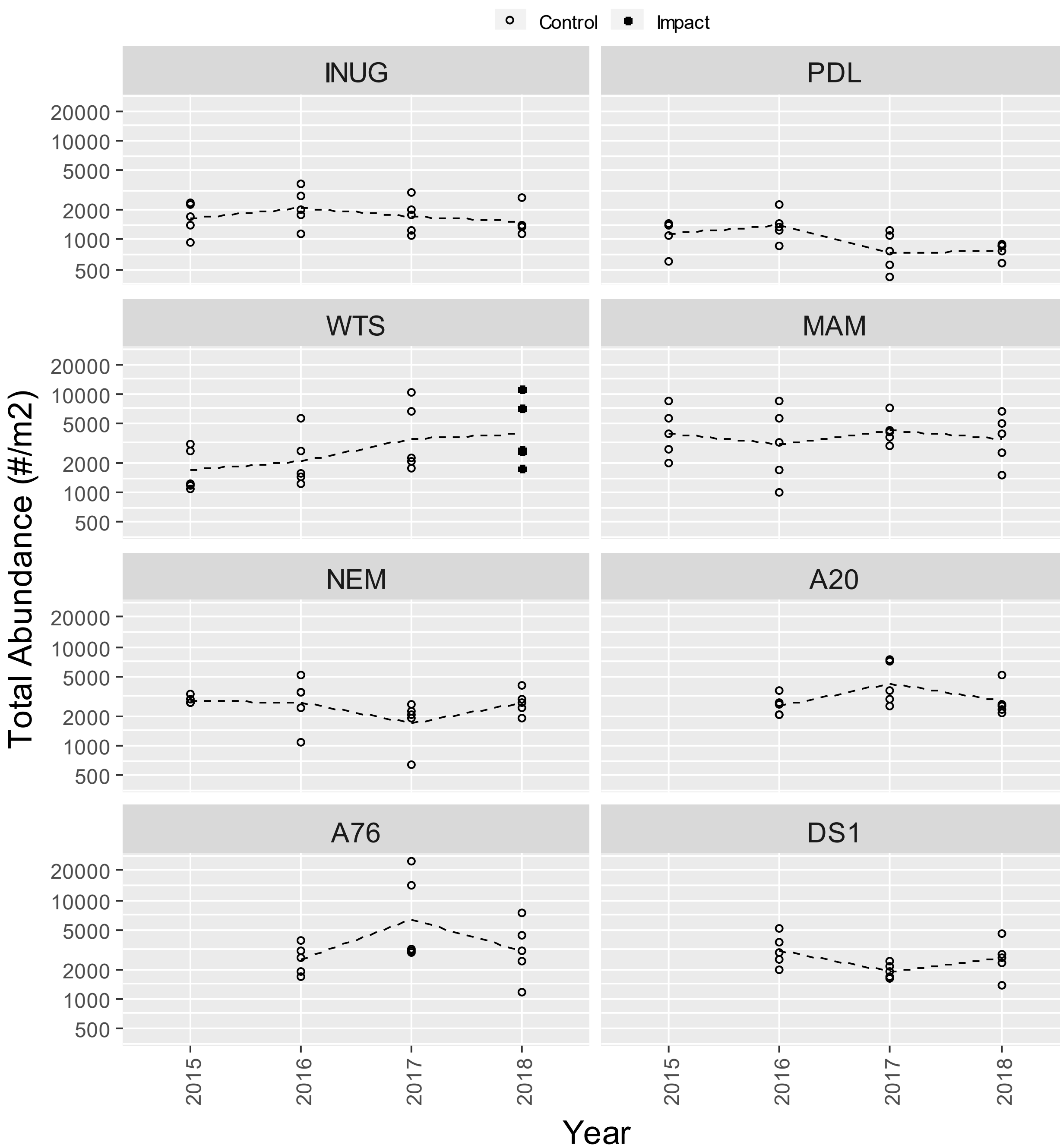


Figure 5-52. Benthic invertebrate abundance (#/m^2) by major taxa group from Whale Tail study area lakes since 2015.

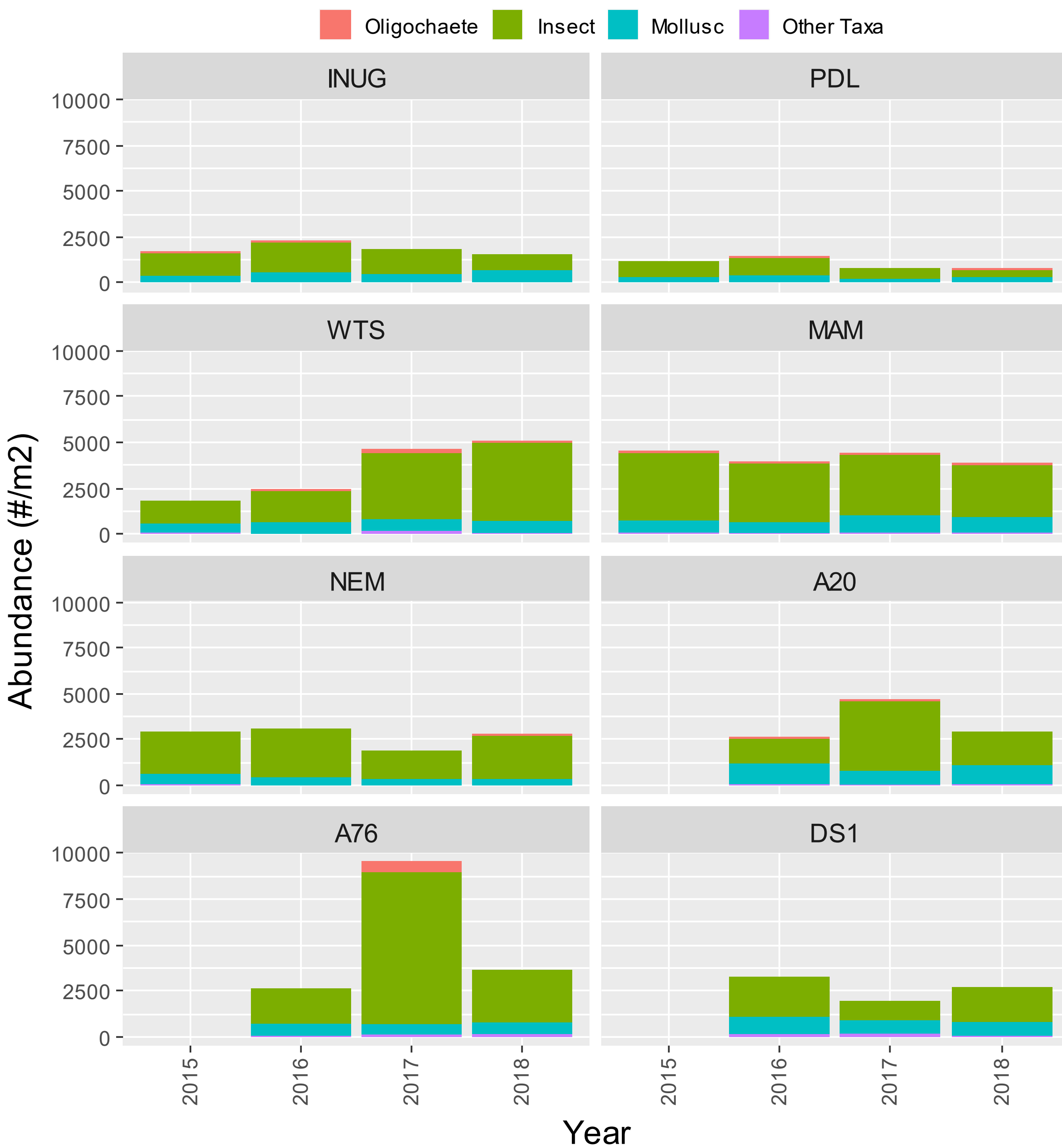


Figure 5-53. Benthic invertebrate relative abundance by major taxa group from Whale Tail study area lakes since 2015.

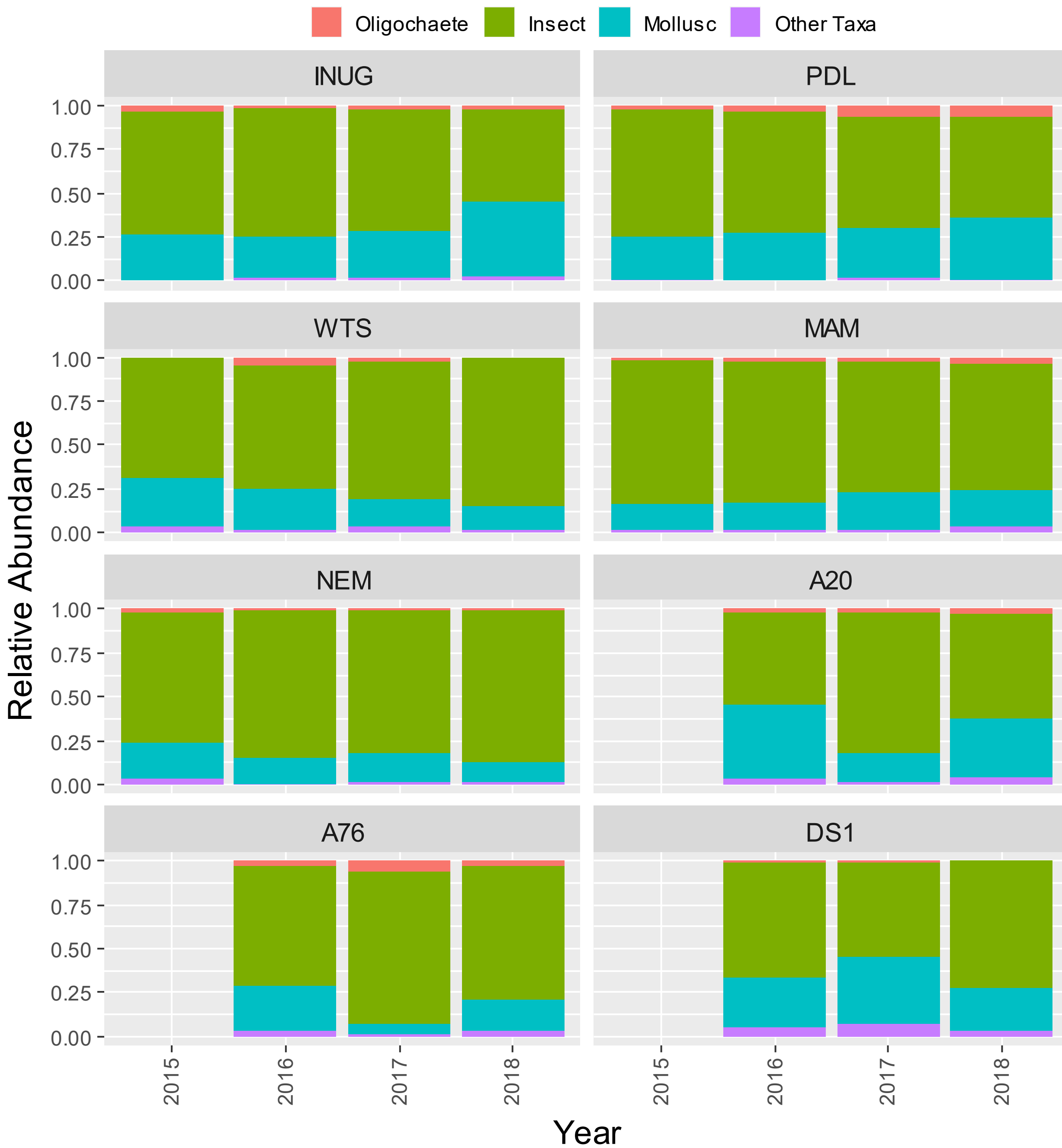


Figure 5-54. Benthic invertebrate total richness (# taxa) from Whale Tail study area lakes since 2015.

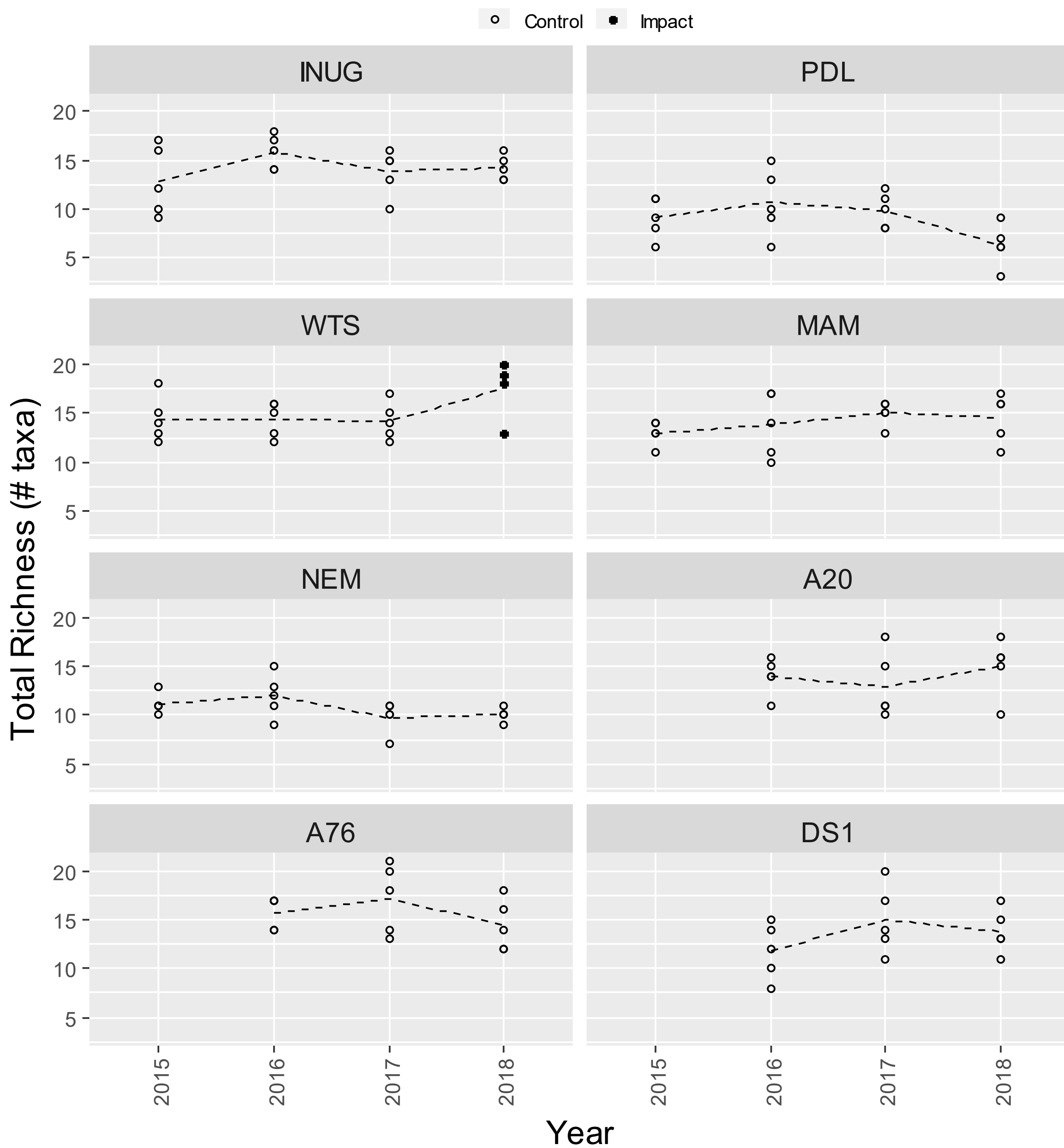


Figure 5-55. Benthic invertebrate richness (# taxa) by major taxa group from Whale Tail study area lakes since 2015

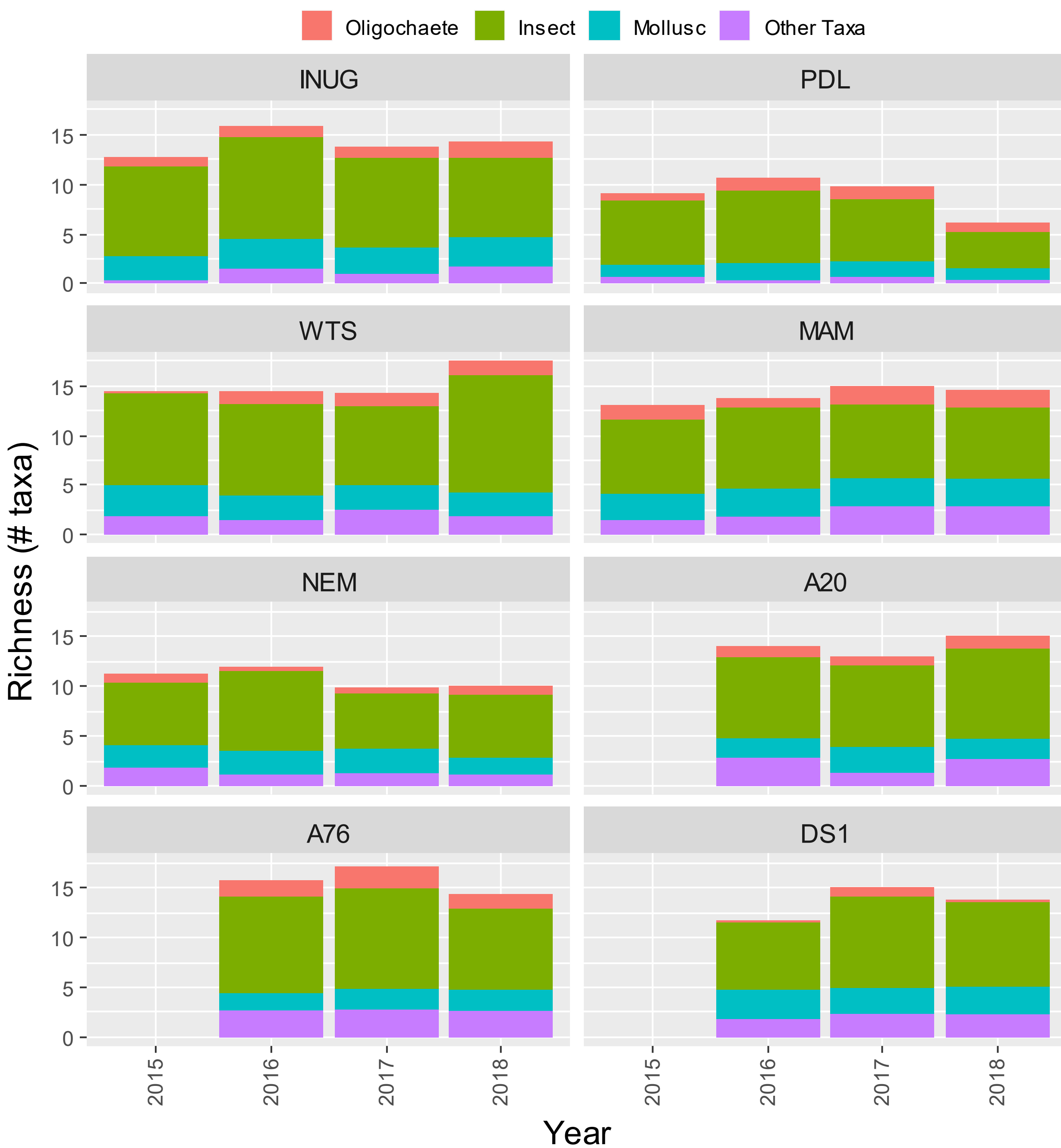


Figure 5-56. Benthic invertebrate relative richness by major taxa group from Whale Tail study lakes since 2015.

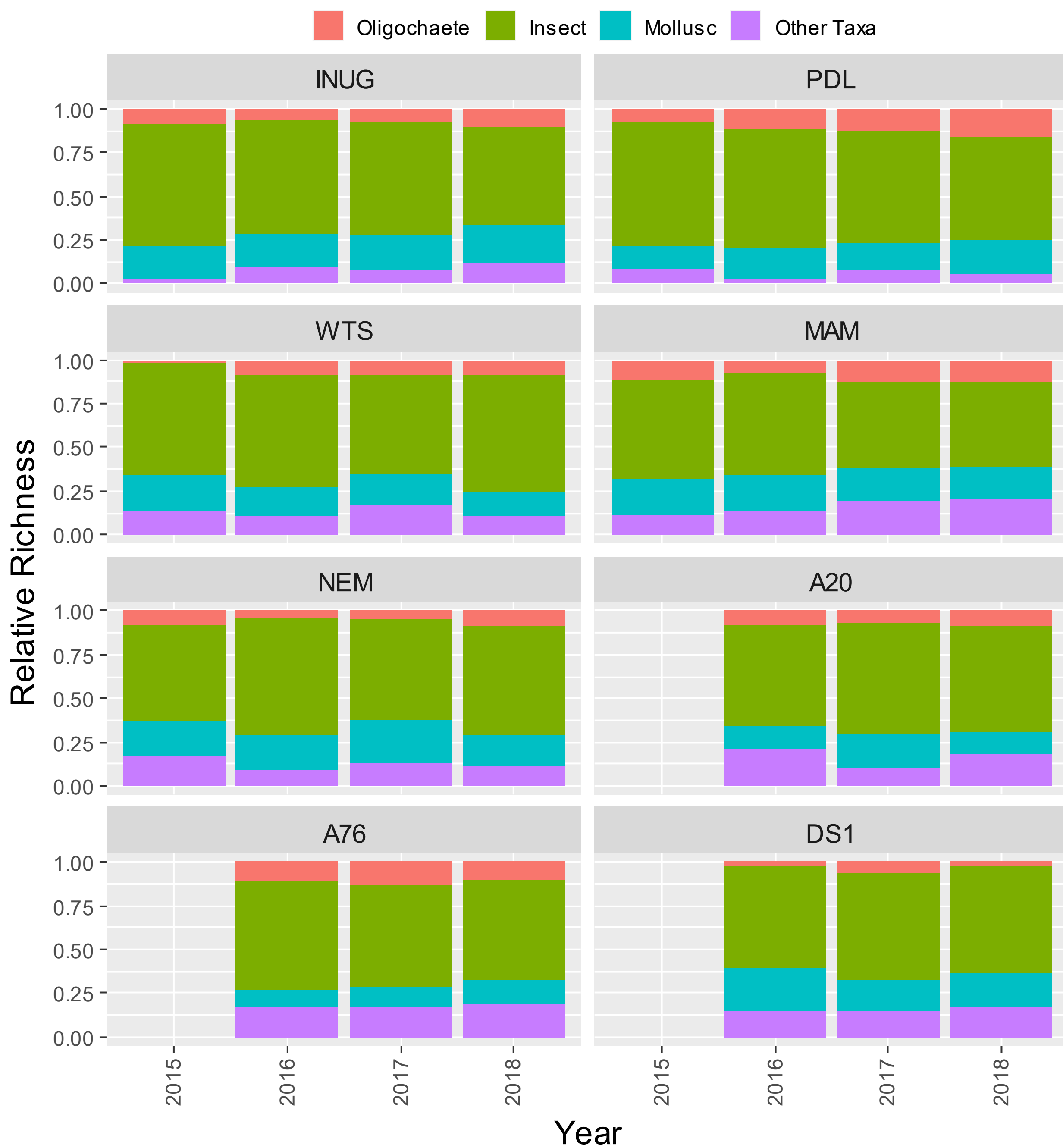


Table 5-2. Benthic invertebrate abundance and richness by major taxa group from the Whale Tail study area lakes, 2018.

Area-Replicate	Depth (m)	Abundance (#/m²)					Richness (# taxa)				
		Oligo	Insects	Molluscs	Other Taxa	**Total**	Oligo	Insects	Molluscs	Other Taxa	**Total**
Whale Tail South Basin (WTS)											
Rep 1	7.2	43	1891	804	22	2761	2	13	3	1	19
Rep 2	8.3	0	2152	391	130	2674	0	14	2	2	18
Rep 3	7.8	43	6500	565	109	7217	2	13	3	2	20
Rep 4	7.9	87	9478	1152	261	10978	2	11	2	3	18
Rep 5	7.2	22	1065	565	109	1761	1	8	2	2	13
Area Mean		***39***	***4217***	***696***	***126***	***5078***	***1***	***12***	***2***	***2***	***18***
Mammoth Lake (MAM)											
Rep 1	8.0	43	696	674	87	1500	2	8	3	3	16
Rep 2	7.9	130	2783	978	87	3978	2	8	3	4	17
Rep 3	8.1	87	4022	609	261	4978	1	6	2	2	11
Rep 4	8.6	261	4783	1217	261	6522	2	5	3	3	13
Rep 5	8.4	43	1783	543	130	2500	2	8	3	3	16
Area Mean		***113***	***2813***	***804***	***165***	***3896***	***2***	***7***	***3***	***3***	***15***
Lake A20											
Rep 1	7.6	0	870	1152	87	2109	0	6	1	3	10
Rep 2	8.0	87	1022	1413	130	2652	1	11	2	4	18
Rep 3	8.9	43	1239	891	326	2500	1	9	2	4	16
Rep 4	8.2	174	4348	522	174	5217	2	8	3	2	15
Rep 5	7.7	109	1196	1000	22	2326	2	11	2	1	16
Area Mean		***83***	***1735***	***996***	***148***	***2961***	***1***	***9***	***2***	***3***	***15***

Area-Replicate	Depth (m)	Abundance (#/m²)					Richness (# taxa)				
		Oligo	Insects	Molluscs	Other Taxa	**Total**	Oligo	Insects	Molluscs	Other Taxa	**Total**
Lake A76											
Rep 1	8.2	0	3630	696	87	4413	0	8	2	2	12
Rep 2	8.8	43	1913	391	87	2435	1	9	1	3	14
Rep 3	8.9	304	5435	1348	348	7435	3	7	3	5	18
Rep 4	8.1	22	630	522	0	1174	1	8	3	0	12
Rep 5	7.9	43	2391	370	217	3022	2	9	1	4	16
Area Mean		***83***	***2800***	***665***	***148***	***3696***	***1***	***8***	***2***	***3***	***14***
Lake DS1											
Rep 1	9.2	0	3804	761	65	4630	0	8	3	2	13
Rep 2	8.6	0	1783	739	109	2630	0	8	2	1	11
Rep 3	8.8	22	1543	609	174	2348	1	8	4	2	15
Rep 4	9.2	0	2087	696	43	2826	0	8	3	2	13
Rep 5	9.5	0	587	609	174	1370	0	10	2	5	17
Area Mean		***4***	***1961***	***683***	***113***	***2761***	***0.2***	***8***	***3***	***2***	***14***
Nemo Lake (NEM)											
Rep 1	6.9	22	2435	239	0	2696	1	8	2	0	11
Rep 2	8.4	22	1609	217	22	1870	1	6	2	1	10
Rep 3	6.2	0	2696	174	87	2957	0	7	1	2	10
Rep 4	7.8	22	1848	522	22	2413	1	5	2	1	9
Rep 5	8.2	43	3348	522	130	4043	1	5	2	2	10
Area Mean		***22***	***2387***	***335***	***52***	***2796***	***0.8***	***6***	***2***	***1***	***10***

Notes

1. Oligo = oligochates

2. Other taxa: (Turbellaria, Acalyptonotidae, Hygrobatidae, Lebertiidae, Oxidae, and Notostraca).

Sediment Toxicity Tables and Figures

Table 5-3. *Chironomus dilutus* survival (%) and growth (mg dry weight) reported in the baseline sediment toxicity tests for the Whale Tail Project.

	C. dilutus Survival (%)					% Survival		
Treatment [1]	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Mean	SD	Effect Size[1]
Control	90	90	100	100	80	92	8.4	-
PDL	90	80	100	100	100	94	8.9	-
INUG	100	100	90	90	90	94	5.5	-
MAM	80	80	100	80	80	84	8.9	-1%
WTN	80	90	90	100	90	90	7.1	6%

	Mean wt./organism (mg)					wt./Sample		
Treatment [1]	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Mean	SD	Effect Size[3]
Control	1.86	2.16	1.64	1.58	2.10	1.87	0.26	-
PDL	2.49	2.44	2.19	2.29	2.19	2.32	0.14	-
INUG	2.26	2.29	2.36	2.48	2.34	2.35	0.09	-
MAM	2.76	2.06	2.47	2.40	2.31	2.40	0.25	14%
WTN	2.03	2.44	2.09	2.09	1.93	2.12	0.19	1%

Notes:

1. Statistically significant differences from the control treatments: laboratory (a), INUG (b), and PDL (c)
2. Mean effect size ratings calculated relative to the mean of the pooled reference data for INUG and PDL

Negligible	<10% reduction in mean survival or growth
Low	10-20% reduction in mean survival or growth
Moderate	20-50 % reduction in mean survival or growth
High	> 50 % reduction in mean survival or growth

Table 5-4. *Hyalella azteca* survival (%) and growth (mg dry weight) reported in the baseline sediment toxicity tests for the Whale Tail Project.

	H. azteca Survival (%)					% Survival		
Treatment [1]	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Mean	SD	Effect Size[2]
Control	90	100	90	100	100	96	5	-
PDL	90	100	100	100	100	98	0	-
INUG	70	100	90	100	100	92	5	-
MAM	100	100	100	100	100	100	0	5%
WTN	90	60	100	100	90	88	18.9	-7%

	Mean wt./*organism* (mg)					wt./Sample		
Treatment [1]	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Mean	SD	Effect Size[3]
Control	0.12	0.24	0.20	0.22	0.21	0.20	0.05	-
PDL	0.22	0.20	0.20	0.22	0.14	0.20	0.03	-
INUG	0.19	0.18	0.20	0.19	0.20	0.19	0.01	-
MAM	0.20	0.18	0.18	0.27	0.22	0.21	0.04	9%
WTN [a,b,c]	0.10	0.06	0.14	0.09	0.17	0.11	0.04	-43%

Notes:

1. Statistically significant differences from the control treatments: laboratory (a), INUG (b), and PDL (c)
2. Mean effect size ratings calculated relative to the mean of the pooled reference data for INUG and PDL

Negligible	<10% reduction in mean survival or growth
Low	10-20% reduction in mean survival or growth
Moderate	20-50 % reduction in mean survival or growth
High	> 50 % reduction in mean survival or growth

6. BAKER LAKE

6.1. Overview of the 2018 Baker Lake CREMP

This section summarizes the results of the 2018 CREMP related to monitoring water quality, sediment chemistry, phytoplankton, community, and benthic invertebrate communities in Baker Lake in 2018.

Baker Lake was added to the core program to ensure that monitoring was also in place to track activities in that area related primarily to barge traffic and shipping. There are two near-field impact areas, one targeting the hamlet's barge landing area (BBD) and the other Agnico Eagle's fuel storage facility (BPJ). The initial (since 2008) reference area (BAP) is several kilometers to the east of the hamlet along the north shore of the lake. A second reference area (BES) was added in 2011 to provide a broader perspective for temporal patterns in sediment chemistry and benthic community structure (n.b., this area is not monitored for water quality or phytoplankton community). Sampling location are shown in **Figure 6-1.**

The number of barge trips from Chesterfield Inlet in 2018 were 36 for general cargo and 19 for fuel (**Figure 6-2**). The number of fuel trips in 2018 is consistent with recent years, but approximately double the number of good shipments happened in 2018 related to development of the Whale Tail Project.

6.2. Limnology

6.2.1. General Observations

Baker Lake is a large lake with much greater wind fetch than the Meadowbank lakes and a unique limnology, due partly to its proximity to tidally influenced Chesterfield Inlet, influence of the Thelon River and deep water that is naturally elevated in dissolved solids. These natural complexities interact, leading to the "competing" influences of less-saline Thelon River water and more-saline Baker Lake water. Timing of sampling relative to freshet on the Thelon River, coupled with shifts in north/south wind speed and direction lead to variable degrees of horizontal and vertical mixing of the water column. When sampling near to the north shore, these factors may combine to confound the detection of potential subtle changes in water quality related to barge activity, with the "signal" getting lost in the "noise" of natural variability in this dynamic location.

The following parameters are associated with more-saline or higher conductivity water that appears to be present in deep water (>10-15 m) and demonstrate considerable fluctuations within and between years. These include conductivity, hardness, calcium, chloride, magnesium, sodium and TDS. Other parameters also have a high level of natural variability and appear to be correlated with the above parameters in Baker Lake and include ammonia, nitrate, TKN, total phosphorus, sulphate and TOC/DOC. A deep limnology survey was conducted in August 2012 to explicitly explore this situation. While just one "snapshot" of this dynamic limnological process, all parameters measured (temperature, conductivity, dissolved oxygen, pH, total dissolved solids and salinity) showed a strong and abrupt stratification from 8 m to 12 m depth at areas BBD 1 and 2, and BPJ. For example, conductivity increased from <20 µS/cm in shallow, near-shore water, to >200 µS/cm between 8 and 12 m depth, depending on location. Conductivity remained uniformly high to the maximum depth sampled (40 m). The implication of this is that results for any event will reflect the relative influence of the deeper, brackish Baker Lake water and the less-saline Thelon River water on the day of the event.

6.2.2. Temporal and Spatial Trend Interpretation

The major mine-related activity that occurs in this area is seasonal barge traffic during the summer months when Baker Lake is ice-free. It should also be noted that the Hamlet of Baker Lake's sewage lagoons and landfill are situated in a watershed that discharges seasonally into Baker Lake between BBD and BPJ. Locally, propeller wash may cause vertical mixing in very discrete areas when there is active traffic. Otherwise (with the exception of spills and occasional discharge from commercial vessels etc.), there are no other activities with the potential to alter limnological parameters.

At Baker Lake, limnological conditions are similar to the Meadowbank study lakes except that water temperatures are cooler, typically reaching no more than 10°C in mid-summer. Mean temperatures at all locations were generally low in 2018 staying constant between 5 and 6°C (**Figure 6-3**). Some thermal stratification is often evident in Baker Lake, particularly in July and August; however, there was very little thermal stratification detected in 2018 (**Figure 6-4**). In contrast to recent years (e.g., 2016 and 2017) Baker Lake areas did not show evidence of warming or stratification despite the August sampling event taking place in late August when typical seasonal warming may be strongest; this is likely due to wind-driven mixing (see below). By the end of September, limnology profiles at all Baker areas resembled conditions in early July just after ice came off the lake (i.e., un-stratified colder water, well-mixed in terms of conductivity [<40 µS/cm], and saturated DO).

As described in **Section 6.2.1**, conductivity can show a strong and abrupt stratification in Baker Lake. The July profile for BBD (**Figure 6-4**) shows a weak stratification pattern related to the influence of the Thelon River and limited mixing. However, for August and September stratification patterns were not present. The relatively low temperatures are also evidence of a well-mixed water column. Field crews completing the sampling program in August 2018 provided the qualitative assessment that conditions were windier than previous seasons which likely explains the well mixed conditions in Bake Lake – Baker Lake is large and open, and winds can generate large waves providing good conditions for mixing.

6.3. Water Chemistry

6.3.1. General Observations

As discussed in **Section 6.2**, Baker Lake is very large and exposed to high wind and wind-generated currents. Monitoring areas along the north shore also have the added complexity of two different water masses: the less-saline Thelon River (discharges into Baker Lake at its western end) and the saline-influenced deeper water in Baker Lake. Depending on wind speed and direction, water from these two sources (e.g., individually or mixed) can strongly influence certain surface water chemistry parameters (conductivity, salts, and dissolved solids). Consequently, there can be pronounced spatial (horizontal and vertical) and temporal variability in certain parameters. While this variability affects many of the "conventional" parameters (as described above), concentrations of many contaminant-related parameters (e.g., metals) in the Baker Lake samples are typically below laboratory MDLs.

6.3.2. Temporal and Spatial Trend Interpretation

CREMP monitoring results since 2008 were used to assess temporal and spatial trends related to mining activities. The general rationale for assessing these trends was discussed in **Section 1.5**; the process was tailored slightly for water chemistry, as described below.

Baker Lake water chemistry results for 2018, screened against site-specific triggers and thresholds, are tabulated in **Appendix B3**. Most water quality parameters in Baker Lake, across all years, are routinely below laboratory MDLs, similar to the results for the Meadowbank study lakes. Detection of changes to water quality related to barge activity (or related to potential non-mining inputs from the Hamlet of Baker Lake) would be relatively easy to detect, notwithstanding the confounding influence of naturally elevated conductivity, dissolved salts and TDS depending on limnological conditions at the time of sampling. In an effort to focus on parameters detected above MDLs at least some of the time, a conservative two-step screening process was used to refine the list parameters for inclusion into the formal trend assessment:

1. Overall Detection Frequency - Only those water quality parameters that exceeded MDLs in at least 10% of the samples were included in this discussion. Because this lake is ultra-oligotrophic, it is normal for many parameters to routinely be below MDLs.

2. Control-Impact Detection Frequency Comparison – In order to avoid screening out infrequently detected parameters that were detected more often in association with barge activities, the proportion of samples exceeding MDLs between “control” and “impact” samples were compared; the intent of this screen was to identify parameters with <5% detection frequency (i.e., those screened out above) for which there were detection frequency changes potentially associated with mining activity (i.e., where the proportion of detected values increased by 0.05 or more).

The screening results are summarized in **Table 6-1** with figure number references (**Figure 6-5** to **Figure 6-51**) for all parameters that were screened in to the assessment process. The samples were collected from a depth of 3 meters for all areas and events, consistent with the SOP. The red dashed line in each of these water chemistry figures is the trigger value specific to Baker Lake for that parameter. All parameters not retained for the trend assessment were assumed to have no spatial or temporal trends related to barge activities or to natural variability and were excluded from further consideration (for completeness and transparency, plots for these parameters are included in **Appendix A2**).

Despite the substantial increase in barge traffic in 2018 (**Figure 6-2**), mean concentrations of all parameters in the 2018 Baker Lake samples were below their respective trigger values. This is not surprising given that there were no reported spills in 2018 and that any effects to the water column from prop wash would be ephemeral and would clear quickly with no lingering effects to the water column. There are no follow-up measures for management in 2018 beyond routine CREMP water quality sampling during the open water season.

6.4. Phytoplankton Community

6.4.1. General Observations

The phytoplankton community of Baker Lake is relatively similar to the Meadowbank Lakes despite some seasonal differences in water quality due to the competing influences of less saline water from the Thelon River and more saline water from the deeper portion of Baker Lake (see **Section 6.2**). Taxonomic composition and biomass in Baker Lake were similar to the Meadowbank study lakes, with chrysophytes (golden algae; e.g., Chrysococcus, Kephyrion, Dinobryon) comprising the dominant taxonomic group since monitoring began in 2008. Cryptophytes and diatoms typically comprise the second and third most abundant groups in Baker Lake as shown in **Figure 6-54**. Mean summer phytoplankton biomass in Baker Lake is generally similar to the Meadowbank lakes, reaching a maximum of between 200 to 300 mg/m^3.

6.4.2. Temporal and Spatial Trend Interpretation

Sampling at the Baker Lake areas is only conducted during the summer open water period (which coincides with barge activity). Because of the large size of Baker Lake, it is unlikely that barge traffic (in the absence of a fuel or chemical spill) could influence whole-lake phytoplankton community.

The 2018 density and biomass results for phytoplankton are tabulated in **Appendix D**. The results for the BACI model statistical tests of the 2018 results against baseline/reference conditions are provided in **Table 6-2**. Major findings at Baker Lake areas in 2018 for chlorophyll-a, total biomass, taxa richness and major taxa group composition were as follows:

- **Chlorophyll-a** – Concentrations at reference area BAP historically range between 0.4 to 1.5 µg/L (**Figure 6-52**). In 2018, maximum chlorophyll-a concentrations, up to 1.5 µg/L, were measured in July. Overall, range and pattern of chlorophyll-a concentrations in 2018 for three Baker Lake areas were similar relative to previous years.
- **Total biomass** – Phytoplankton biomass was broadly lower at BAP, BPJ, and BBD in 2018 relative to previous years. Annual variation in biomass co-vary between the control and BPJ; however, lower biomass between 2017 and 2018 is particularly evident at BBD (**Figure 6-53**). In 2017 there was a non-statistically significant 30% increase in phytoplankton biomass at BBD relative to BAP (p=0.228); this result was likely due in part to the lower biomass in 2017 at reference BAP, combined with natural variability. In 2018, both BBD and BPJ were statistically lower (P<0.1)) than BAP (BBD = -35% change; BPJ = -27% change). The 2018 results for BAP and BPJ were low but generally within the range of other less productive years (e.g., 2013 and 2017). The biomass for BBD is less than previous years, particularly for September (65 mg/m^3 and 56 mg/m^3). However, the lower biomass is likely related, at least in part, the cooler temperatures and greater mixing indicated by the limnology profiles (**Section 6.2**). Both 2017 and 2018 were less productive years in comparison to 2016 (**Figure 6-53**), and limnology profile results from 2017 (Azimuth, 2018c) and 2018 (**Figure 6-4**) indicate colder temperatures and more vertical mixing for all three sampling events in those years compared with 2016 when conditions were noticeably warmer and more stratified (Azimuth, 2017a). While the 2018 results do represent statistically significant reductions in phytoplankton biomass at BBD and BPJ, the lack of any trigger exceedances for water chemistry parameters or any reported spills in 2018 suggest that the leading causal process driving these results is natural variability.
- **Major taxa composition** – there were no apparent differences in relative composition of phytoplankton communities between BAP and impact areas BBD and BPJ in 2018 (**Figure 6-55**). Chrysophytes are the dominant taxa in terms of biomass at the reference and

exposure areas, making up ~40 to 50% of the total phytoplankton biomass in each area. Diatoms, and cryptophytes make up about 20 to 25% each, and the remainder of the biomass is made up of chlorophytes and dinoflagellates (**Appendix D**).

- **Taxa richness** – richness in Baker Lake phytoplankton samples was within the range previously noted for the exposure and reference areas (**Figure 6-56**). There is evidence of seasonal variability in 2018 and different trends appear for different areas – BBD richness trends slightly lower between July and September which BPJ richness appears to increase between July and September. There were no statically significant changes between control area (BAP) and impact areas (BPJ and BBD) over the 20% trigger.

Phytoplankton biomass will continue to be monitored for potential temporal trends, but no follow-up measures are recommended other than routine monitoring for 2019.

6.5. Sediment Chemistry

6.5.1. General Observations

Baker Lake has multiple confounding influences that potentially affect water quality (including potential inputs from the Hamlet of Baker Lake's sewage lagoons and landfill, which are situated in a watershed that discharges seasonally into Baker Lake between BBD and BPJ). Shipping-related influence on sediment metals concentrations would be limited to disturbance of bottom sediments from ship propeller wash and possibly from contaminant introductions (e.g., discharges, leaks, or spills); no spills were reported in 2018.

Grab chemistry data were collected from BAP, BES, BPJ, and BBD synoptic with the benthic invertebrate sampling locations – no core samples were collected in 2018. Five replicate grab samples were collected at each area. The sediment sampling areas are depicted in (**Figure 6-1**).

6.5.2. Temporal and Spatial Trend Interpretation

The 2018 sediment chemistry results for Baker Lake, screened relative to the trigger values specific to Baker Lake, are presented in **Appendix C**

To help with interpretation of long-term temporal and spatial trends, concentrations of individual metals have been plotted in **Figure 6-58** to **Figure 6-65**. Metals concentrations are shown by area for the different sampling methods (grab [data points] vs core samples [box and whisker plots]) – only grabs were collected in 20082018 (so no BA statistical tests were conducted this year); however, core sample results are included for past years for completeness. The red dashed line in each of sediment metals figures is the Baker Lake trigger value. The box and whisker plots illustrate the statistical distribution of core samples within each area. Data interpretation for the box and whisker plots is as follows:

- The horizontal line inside the box represents the median concentration
- The upper and lower margins of the box represent the upper (75th) and lower (25th) percentile concentrations, respectively (the “interquartile” range)
- The vertical lines represent maximum and/or minimum concentrations (provided at least one value falls outside the box but within 1.5 times the interquartile range)
- ‘x’s that occur beyond the maximum or minimum lines represent concentrations that are greater than 1.5 times the interquartile distance and indicate ‘outlier’ concentrations that are real, but don’t fit within the distribution of the rest of the data, for whatever reason.

Baker Lake sediment chemistry results for all metals show no obvious temporal trends since 2008 (**Figure 6-58** to **Figure 6-65**). Arsenic was the only parameter to exceed site-specific trigger values in 2018. However, the lack of any temporal trend suggests that this reflects an inappropriate trigger value rather than changes to sediment quality. This is corroborated by the results of the BA statistical analysis conducted in 2017 on the core sample results, which confirmed that arsenic concentrations were not trending higher. As in previous years, concentrations of hydrocarbons and PAH’s in the composite sediment samples were below their respective MDL’s at the reference and exposure areas (**Appendix C**).

There continues to be no evidence of any barge-related impacts to sediment metals or organics concentrations at impact areas in Baker Lake. The majority of the influence of barge traffic would be disturbance and re-settling of existing sediment particles. Although sediment grain size is inherently different between exposure and reference areas, there was no pattern of change for any metal over time that would suggest metals contamination (e.g., from anti-fouling paint from the hulls of barges).

6.6. Benthos Community

6.6.1. General Observations

Benthic invertebrates have been collected from Baker Lake annually in August since 2008. Baker Lake was added to the core program to ensure that monitoring was also in place to track activities in that area related primarily to barge traffic and shipping. There are two near-field impact areas, one targeting the hamlet’s barge landing area (BBD) and the other Agnico’s fuel storage facility (BPJ). The initial (since 2008) reference area (BAP) is several kilometers to the east of the hamlet along the north shore of the lake, a second reference area (BES) was added in

2011 to provide a broader perspective for temporal patterns in benthic community structure (**Figure 6-1**).

Abundance and species composition of benthic invertebrate communities at Baker Lake are strongly affected by a variety of parameters, including grain size, water depth and sediment organic content (as discussed for the Meadowbank lakes in **Section 4.6.1**). Investigations in the Meadowbank lakes and Baker Lake have targeted areas of similar depth and grain size (i.e., dominated by silt/clay with a small [<5%] sand fraction). Unlike the Meadowbank study lakes, sediment grain size in Baker Lake has tended to be more variable and less predictable at all locations, with consistently coarser grain size (due to more sand) than observed in Meadowbank lakes (see the 2018 results in **Appendix C3** as an example of the variability within, and between areas). Higher sand content is typically associated with a lower TOC concentration, which in turn influences the type of benthic community.

Similar to Meadowbank study lakes, the Baker Lake benthic community is generally characterized by relatively low abundance and taxa richness. Benthic invertebrate community abundance at Baker Lake often exceeds 2,000 organisms/m^2 (**Figure 6-66**), which is higher than typically-reported benthic invertebrate abundance at the Meadowbank study area lakes (**Figure 6-68**). Annual variability was sometimes high, as seen for example at BBD (e.g., from 2008 to 2009). There have also been fairly consistent spatial differences in abundance between areas (e.g., BBD and BPJ have generally had lower abundance than BAP). Taxa richness historically ranged from 5 to 19 in exposure areas and from approximately 15 to 22 in reference areas, although considerable within-area variability in taxa richness has been documented, particularly at the exposure areas BBD and BPJ (e.g., **Figure 6-68**).

The benthic invertebrate community in Baker Lake is dominated by the aquatic larval stages of insects, especially chironomids (Family Chironomidae), both in terms of abundance (**Figure 6-66** and **Figure 6-67**) and taxa richness (**Figure 6-69** and **Figure 6-70**). The next most abundant group is typically Mollusca (clams) especially, *Cyclocalyx/Neopisidium*, genera of the family Sphaeriidae (fingernail clams). Oligochaete worms can also be relatively abundant in the lake sediments, possibly because of higher sand content; generally, at least one oligochaete taxon was present at most area/year combinations.

6.6.2. Temporal and Spatial Trend Interpretation

Benthic invertebrate abundance and richness results from 2018 are tabulated in **Appendix E3**. Details regarding historical trends are discussed in the 2011 CREMP (Azimuth, 2012a). This report focuses on the 2018 results and trends over the last four years. BACI model results are presented in **Table 6-3** (abundance) and **Table 6-4** (richness). Note that as sampling started in

2008 after development-related activities started, there is no true “before” period and a series of BACI tests is run that compares “control” and “impact” areas over a range of “after” periods (see **Section 2.4.3** for more details). Key results are described below:

- **Total abundance** – Mean 2018 abundance was generally similar to the higher means observed in previous years at all Baker Lake areas (**Figure 6-66**). Overall, there are no obvious temporal trends in total abundance at “impact” areas BBD and BPJ and none of the BACI after period groupings showed statistically significant changes had occurred at the “impact” areas (**Table 6-3**). Interestingly, while the results were not statistically significant, the apparent effect sizes for abundance at both BBD and BPJ in 2018 were above 300% relative to “before”/reference conditions (**Table 6-3**); the trend persists, but to a lessor magnitude, across all four after periods (i.e., up to four years in the “after” period). These results are likely an artefact of natural variability, with three of the top five highest total abundance results occurring in the past four years (and the highest ever recorded occurring in 2018) at both NF areas. The conclusion of natural variability is corroborated by the taxa richness results (see below), which show a general increase in benthic invertebrate taxa diversity over the past four years (including at reference area BES). In summary, there is no indication that barge traffic is having an adverse effect on benthic invertebrate community abundance at the exposure areas in Baker Lake.
- **Major taxa group abundance** – As discussed previously, the benthic invertebrate communities at reference and impact areas in Baker Lake are comprised primarily of chironomid larvae. However, the relative proportion of different taxa is markedly different for the impact areas BBD and BPJ compared to reference are BAP (apart from 2008; **Figure 6-67** and **Figure 6-68**). Since 2009, between approximately 25 to 60% of individuals at BAP have been oligochaetes, compared to less than 10% at the impact areas and reference area BES (which was added in 2011 to provide a reference area with more similar characteristics to the exposure areas). As was the case in recent years, the dominant oligochaete taxa in terms of density at BAP in 2018 were from the Naididae subfamilies Rhyacodrilinae (*Rhyacodrilus* sp) and Tubificinae (see **Appendix E**). *Rhyacodrilus* sp were identified in at least three replicate samples from BES, BBD, and BPJ, but at lower abundances. The differences observed in major taxa composition between the two reference areas, and likely both NF areas, is completely natural.
- **Taxa richness** – Mean taxa richness was high across all Baker Lake areas in 2018 (**Figure 6-69**). Geometric means for total richness were the highest among all years for BES, BBD, and BPJ. Total richness at BAP was the lowest seen in the previous four years, but still higher than results from 2008 to 2014. Consequently, the BACI model results showed positive, yet

uncertain (p>0.1) effects sizes for total richness in 2018 and the 2-year, 3-year, and 4-year time periods (**Table 6-4**). These trends likely reflect of natural variability in the community.

- **Major taxa group richness** – From a taxa richness perspective, impact areas BBD and BPJ appear reasonably similar to both reference areas (BES and BAP), with insects dominating the communities (**Figure 6-70** and **Figure 6-71**). There were no apparent trends in species composition, indicating the barge operations are not adversely affecting the community.

Monitoring results to date have been variable across the sites. A detailed discussion on early trends is presented in the 2012 CREMP (Azimuth, 2013). At present there is no evidence that development-related activities are adversely affecting the benthic invertebrate community, especially in light of no apparent barge-related effects to water quality and sediment chemistry.

6.7. Baker Lake Tables and Figures

The tables and figures for the Baker Lake CREMP are provided in this section except for the large tabulated datasets and figures for parameters that are not included in the detailed analysis (see in-text references to appropriate Appendices). Subsections are provided for each of the CREMP components (e.g., limnology, water chemistry, phytoplankton, sediment chemistry, and benthos).

Legend

- Water Sampling Point
- Sediment/Benthic Invertebrate Quality Sampling Station
- All-Weather Access Road
- Whale Tail Haul Road

0 5 10 15
Kilometres

Projection: UTM Zone 14 NAD83

Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.

Figure 6-1. Baker Lake study area – Water, sediment, and benthic invertebrate areas, 2018

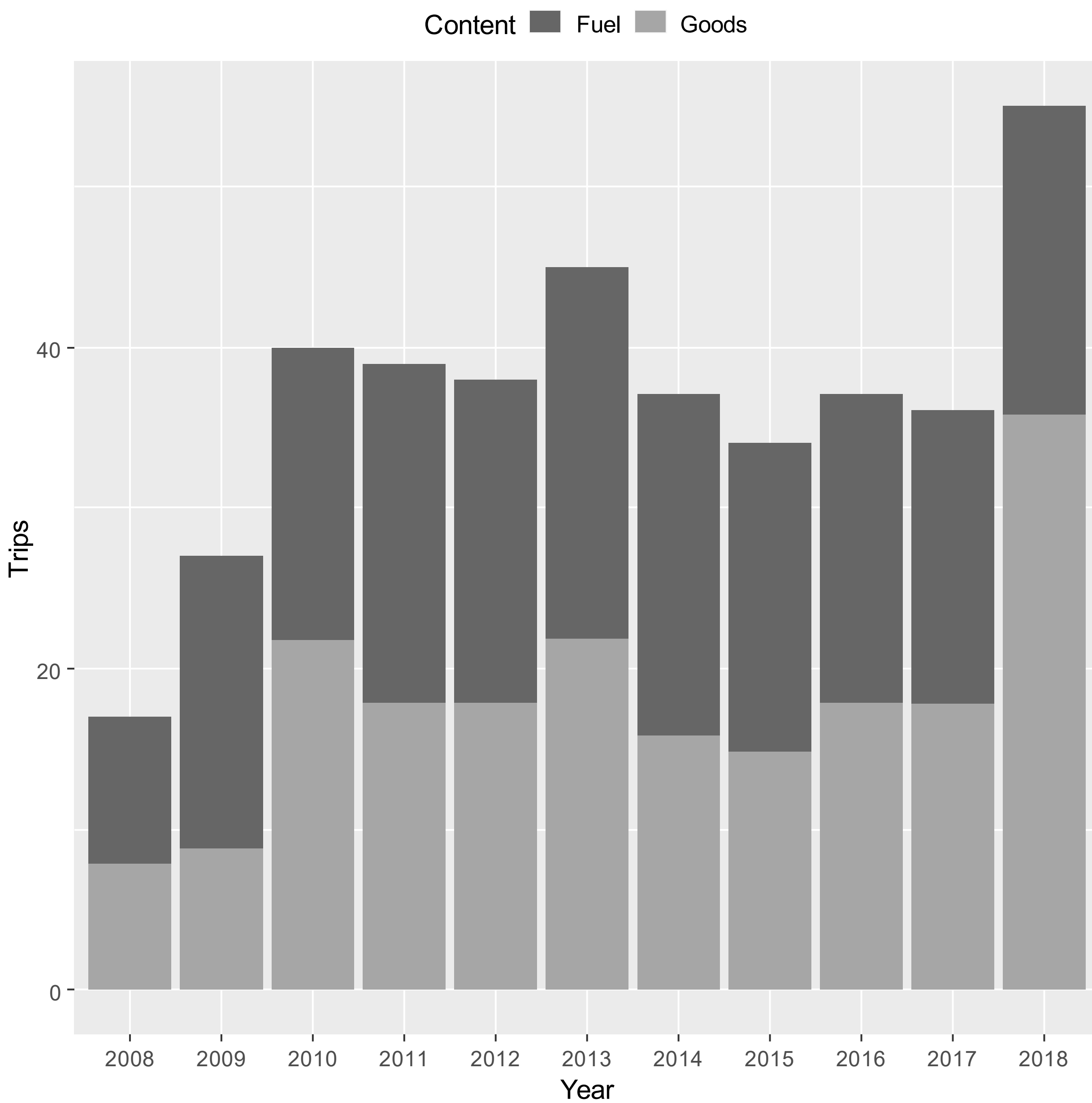
Meadowbank Gold Project

Prepared for: AGNICO EAGLE

By: CASLYS CONSULTING

February 2019

Figure 6-2. Barge traffic (number of trips/year) arriving in Baker Lake from Chesterfield Inlet since 2008.



Limnology Tables and Figures

Figure 6-3. Mean monthly field-measured temperature (°C) at 3 m depth from 2008 – 2018, Baker Lake.

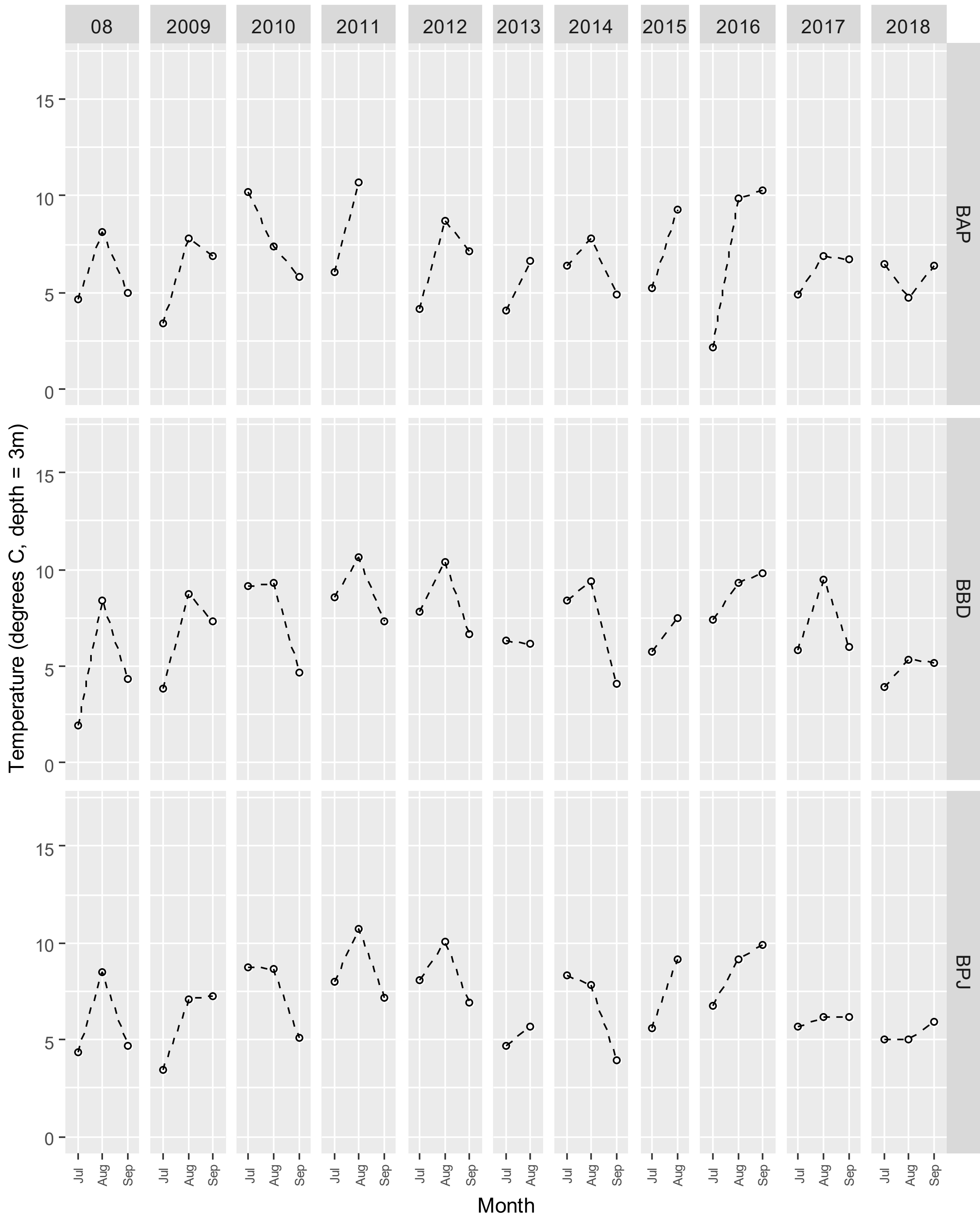
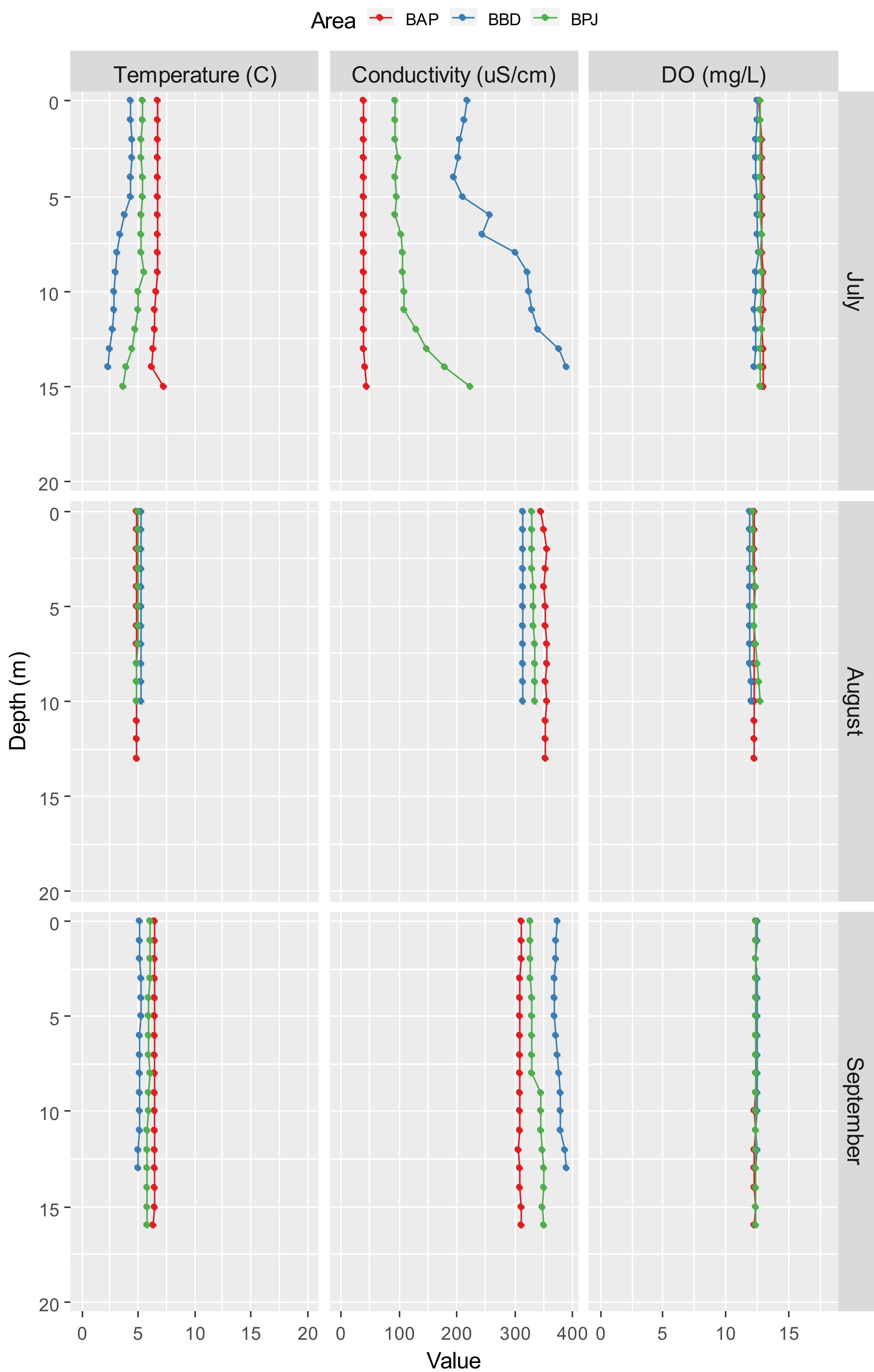


Figure 6-4. Baker Lake – Field-measured temperature, conductivity, and dissolved oxygen profiles, 2018.

Note: Dissolved oxygen concentrations were unstratified and similar among the three areas (values masked).



Water Chemistry Tables and Figures

Table 6-1. Screening process for water quality parameters, Baker Lake, 2018.

CONVENTIONALS		
Screening Level	**1**	**2**
Screening Rule[1]	**>DL ≥ 10% frequency**	**C-I > 0.05 frequency**
Conductivity	Figure 6-5	
Hardness	Figure 6-6	
pH -Field	Figure 6-7	
pH -Lab	Figure 6-8	
TSS	Figure 6-9	
TDS	Figure 6-10	
B-Alkalinity	Figure 6-11	
C-Alkalinity*	No	No
T-Alkalinity	Figure 6-12	
Ammonia-N	Figure 6-13	
Chloride	Figure 6-14	
Nitrate-N	Figure 6-15	
Nitrite-N*	No	No
TKN	Figure 6-16	
T-phosphorous	Figure 6-17	
Ortho-phosphate	Figure 6-18	
Reactive silica	Figure 6-19	
Sulphate	Figure 6-20	
DOC	Figure 6-21	
TOC	Figure 6-22	
T-Cyanide*	No	No
Free Cyanide*	No	No

TOTAL METALS		
Screening Level	**1**	**2**
Screening Rule[1]	**>DL ≥ 10% frequency**	**C-I > 0.05 frequency**
Aluminum	Figure 6-23	
Antimony*	No	No
Arsenic	Figure 6-24	
Barium	Figure 6-25	
Beryllium*	No	No
Boron	Figure 6-26	
Cadmium*	No	No
Calcium	Figure 6-27	
Chromium	Figure 6-28	
Copper	Figure 6-29	
Iron	Figure 6-30	
Lead	No	No
Lithium	Figure 6-31	
Magnesium	Figure 6-32	
Manganese	Figure 6-33	
Mercury*	No	No
Molybdenum	Figure 6-34	
Nickel*	No	No
Potassium	Figure 6-35	
Selenium*	No	No
Sodium	Figure 6-36	
Strontium	Figure 6-37	
Thallium*	No	No
Tin*	No	No
Titanium	Figure 6-38	
Uranium	Figure 6-39	
Vanadium*	No	No
Zinc*	No	No

DISSOLVED METALS		
Screening Level	**1**	**2**
Screening Rule[1]	**>DL ≥ 10% frequency**	**C-I > 0.05 frequency**
Aluminum	Figure 6-40	
Antimony*	No	No
Arsenic	Figure 6-41	
Barium	Figure 6-42	
Beryllium*	No	No
Boron	Figure 6-43	
Cadmium*	No	No
Chromium*	No	No
Copper	Figure 6-44	
Iron	Figure 6-45	
Lead*	No	No
Lithium	Figure 6-46	
Manganese	Figure 6-47	
Mercury*	No	No
Molybdenum	Figure 6-48	
Nickel*	No	No
Selenium*	No	No
Strontium	Figure 6-49	
Thallium*	No	No
Tin*	No	No
Titanium*	No	No
Uranium	Figure 6-50	
Vanadium*	No	No
Zinc	Figure 6-50	

Notes:
"*" Plots for these parameters are presented in **Appendix B3.**
1. See text for further detail.

Figure 6-5. Laboratory-measured conductivity (µS/cm) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake. Laboratory-measured conductivity data from 2014 should be interpreted with caution, particularly at low concentrations (see Azimuth, 2015c for details).

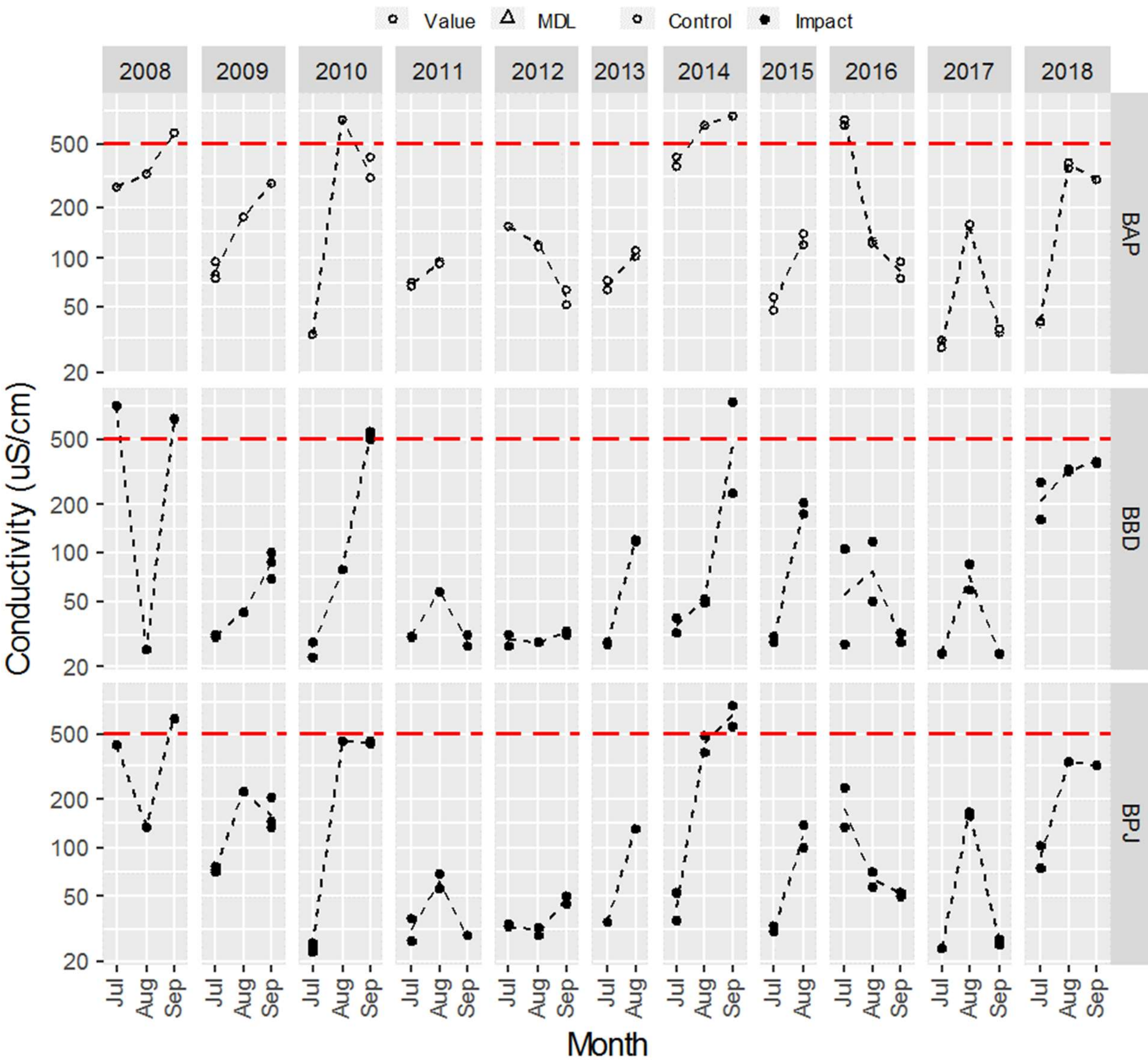


Figure 6-6. Hardness (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

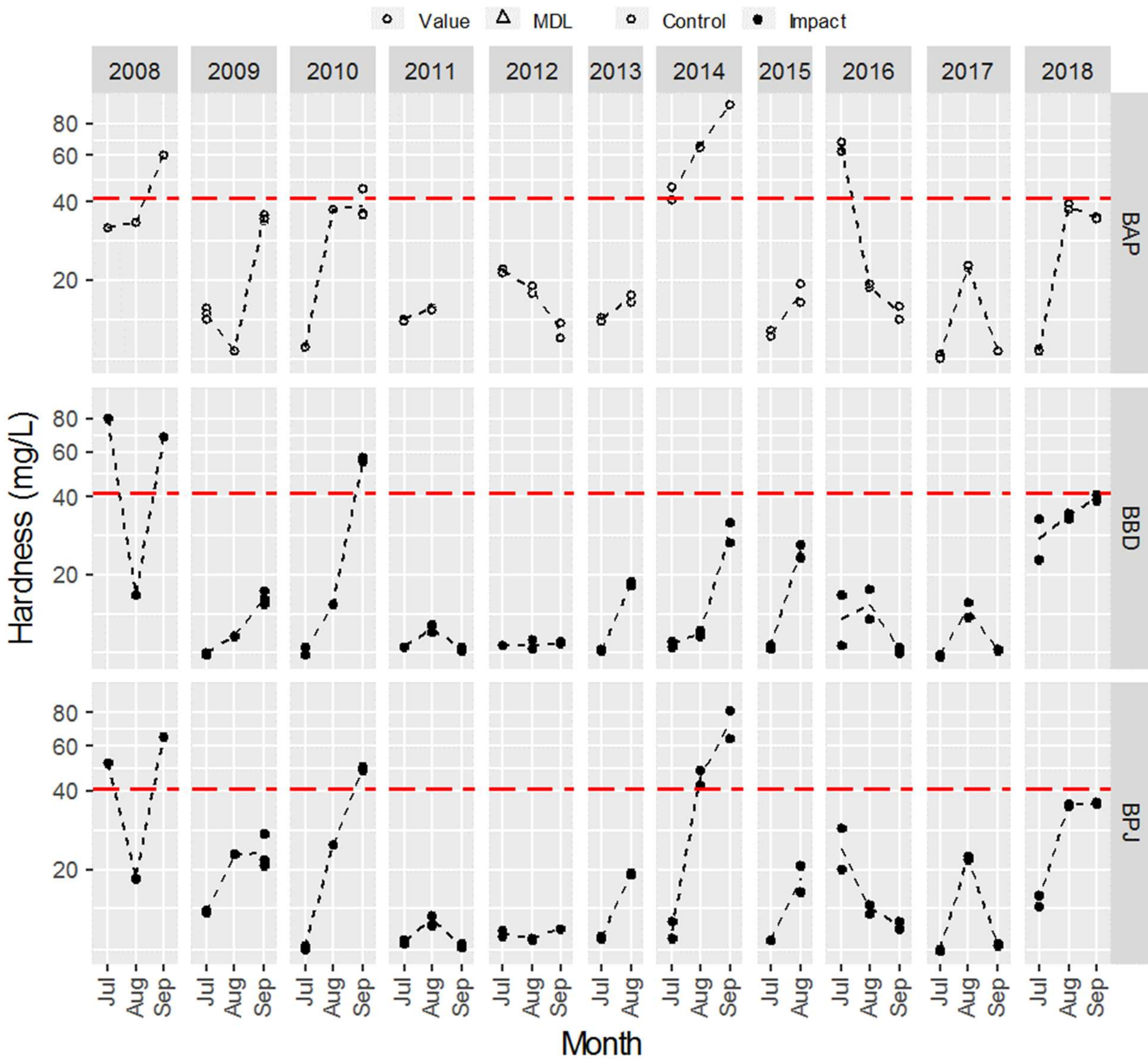


Figure 6-7. Field measured pH in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

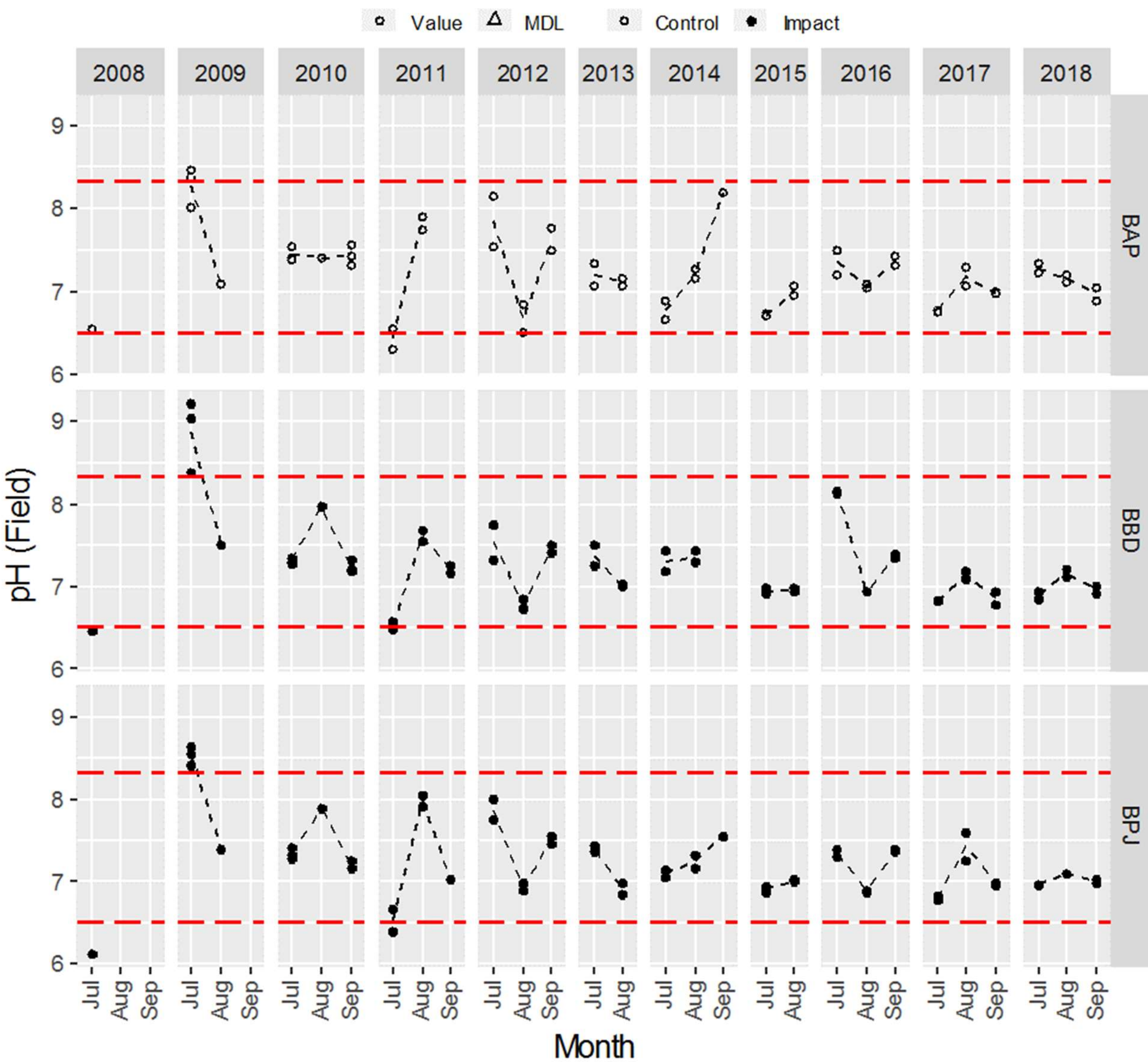


Figure 6-8. Laboratory pH measured in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

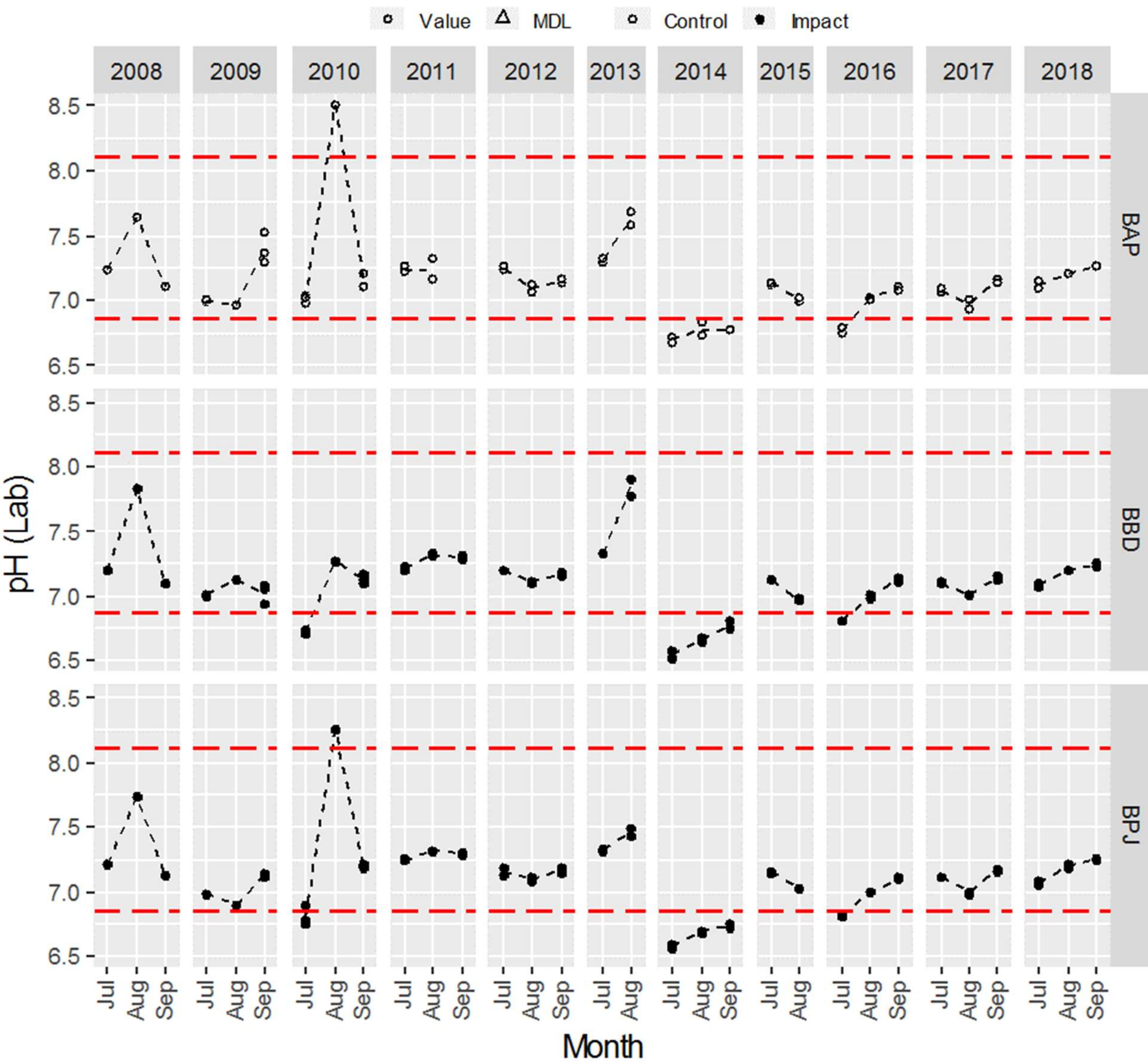


Figure 6-9. Total Suspended Solids (TSS; mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

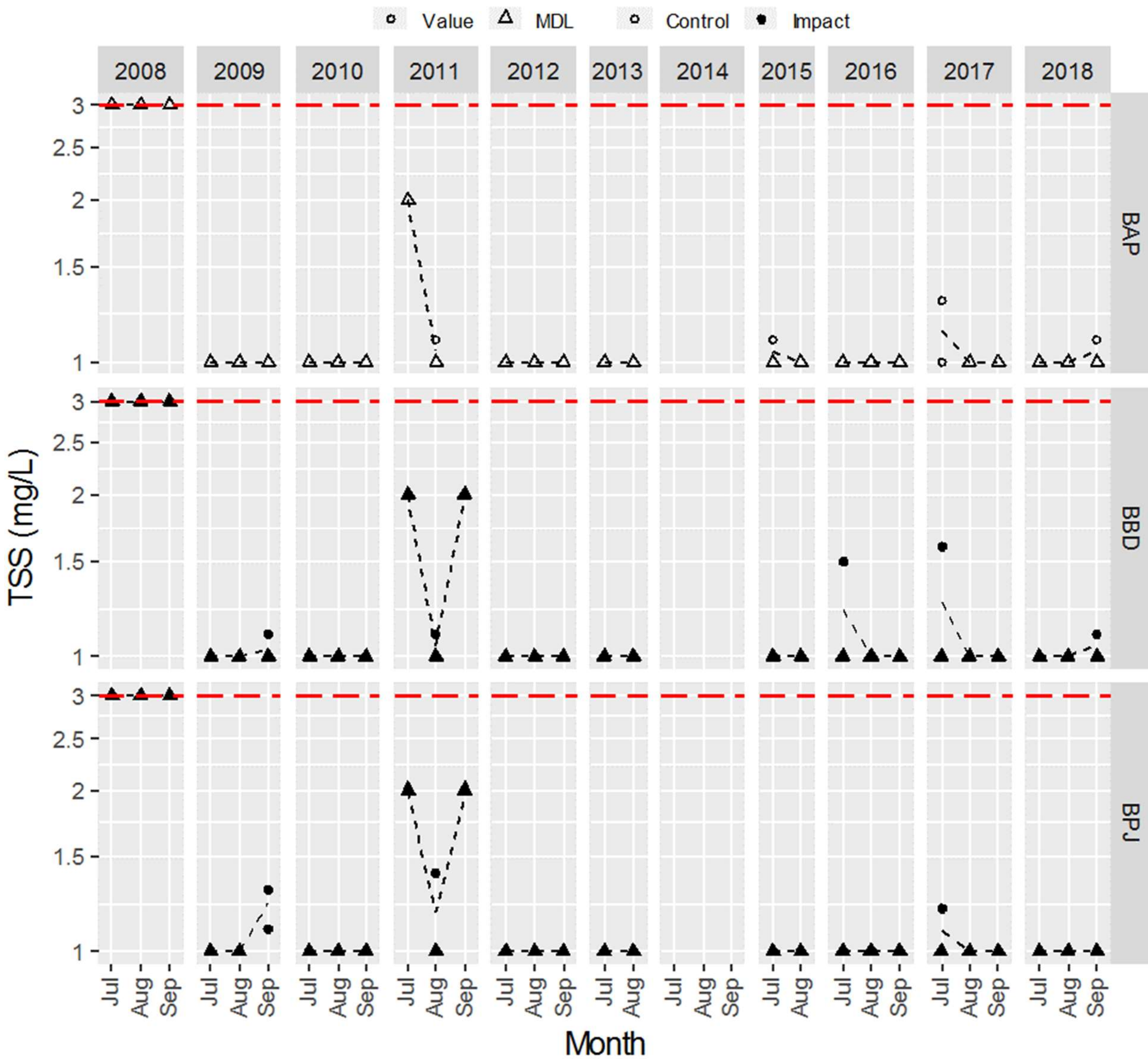


Figure 6-10 Total Dissolved Solids (TDS; mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

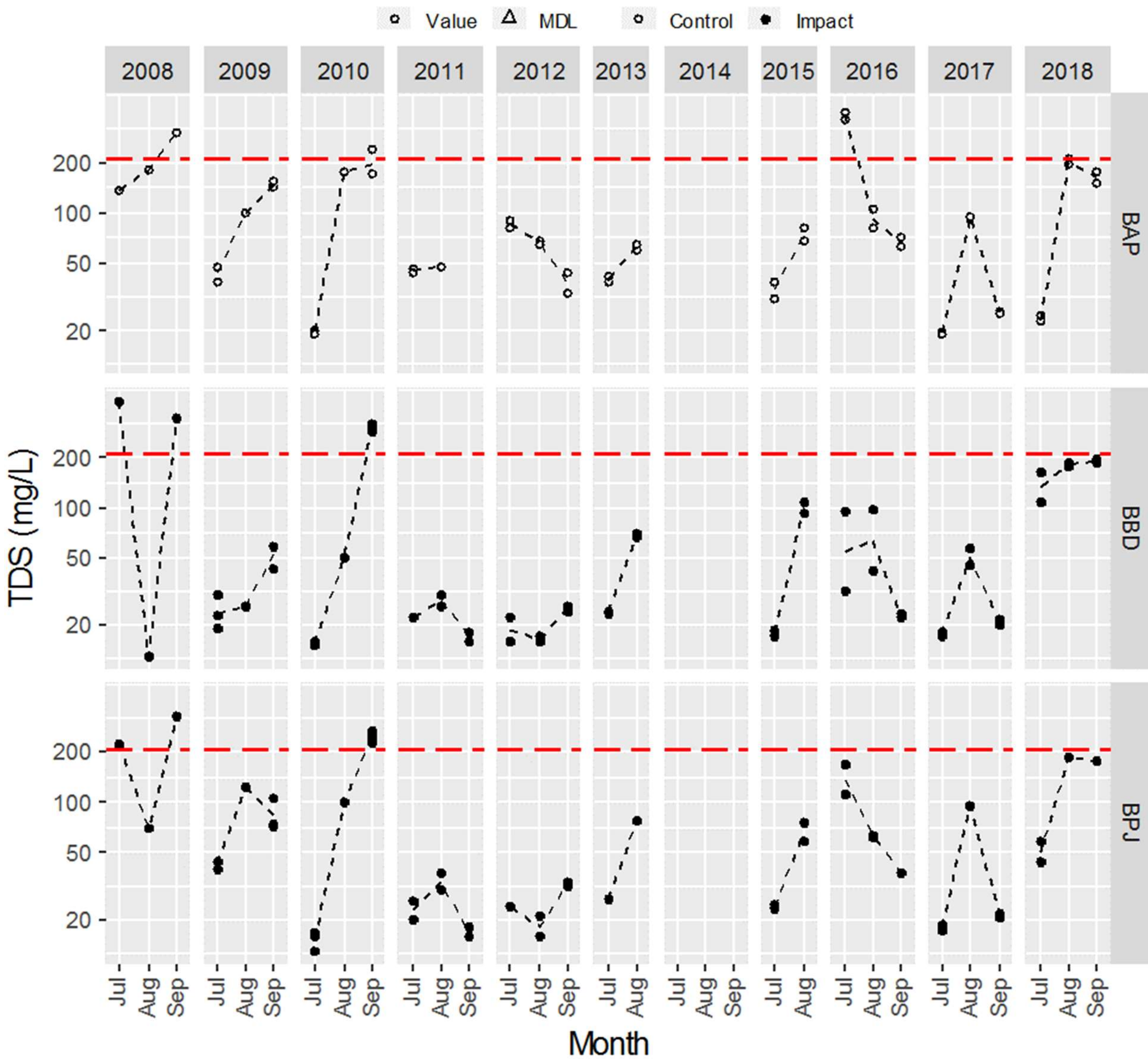


Figure 6-11. Bicarbonate Alkalinity (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

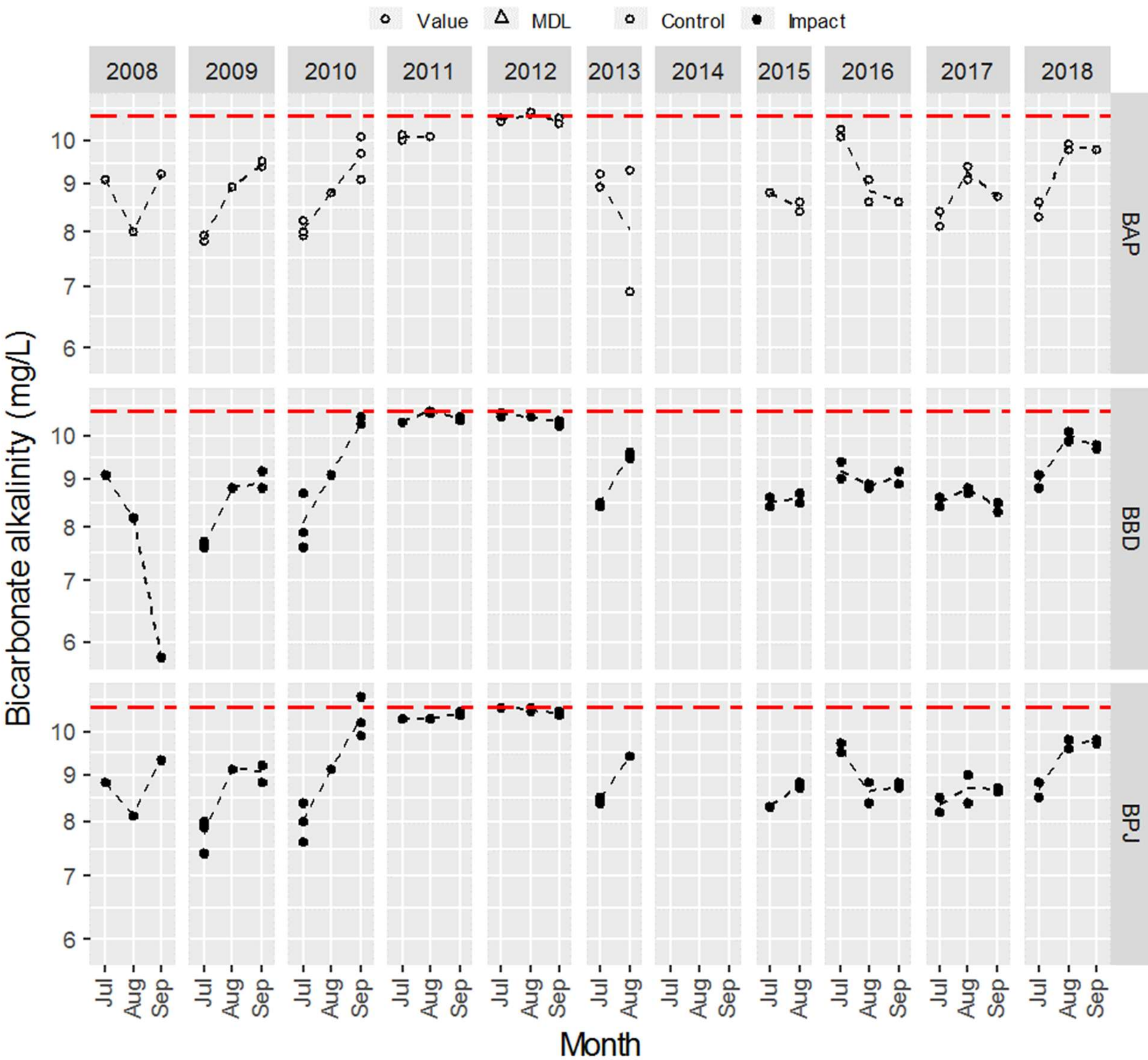


Figure 6-12. Total Alkalinity (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

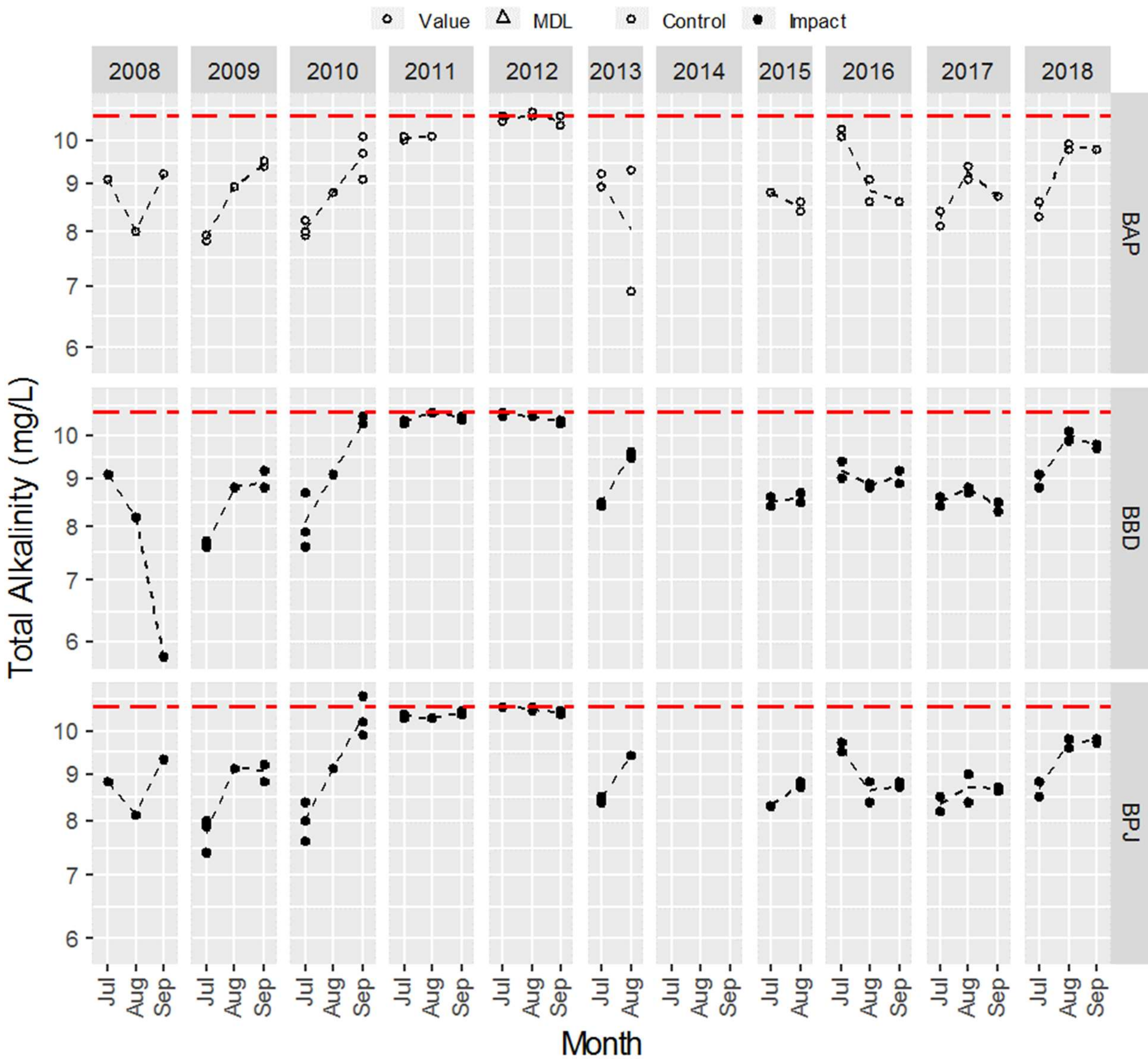


Figure 6-13. Ammonia (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

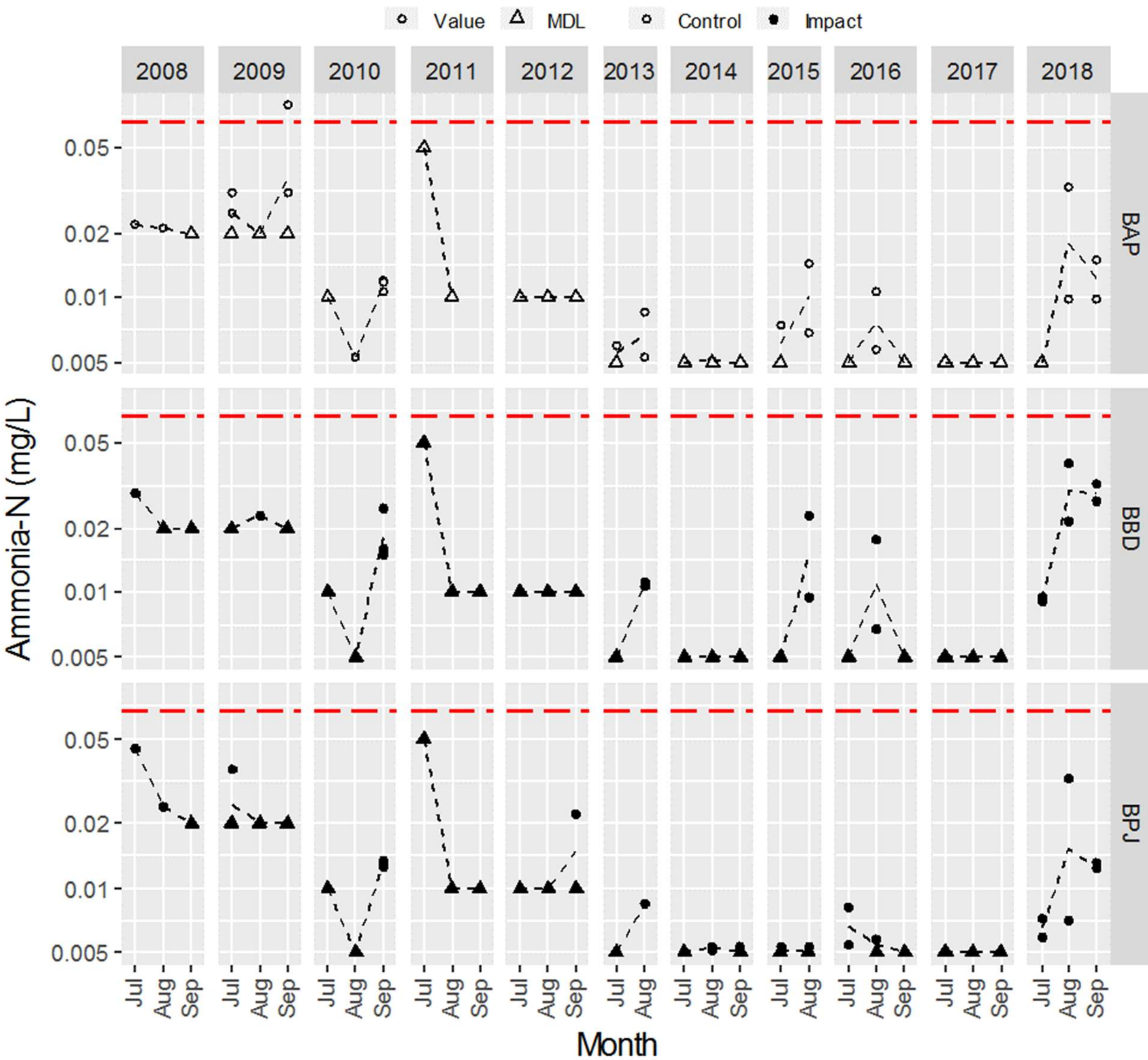


Figure 6-14. Chloride (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

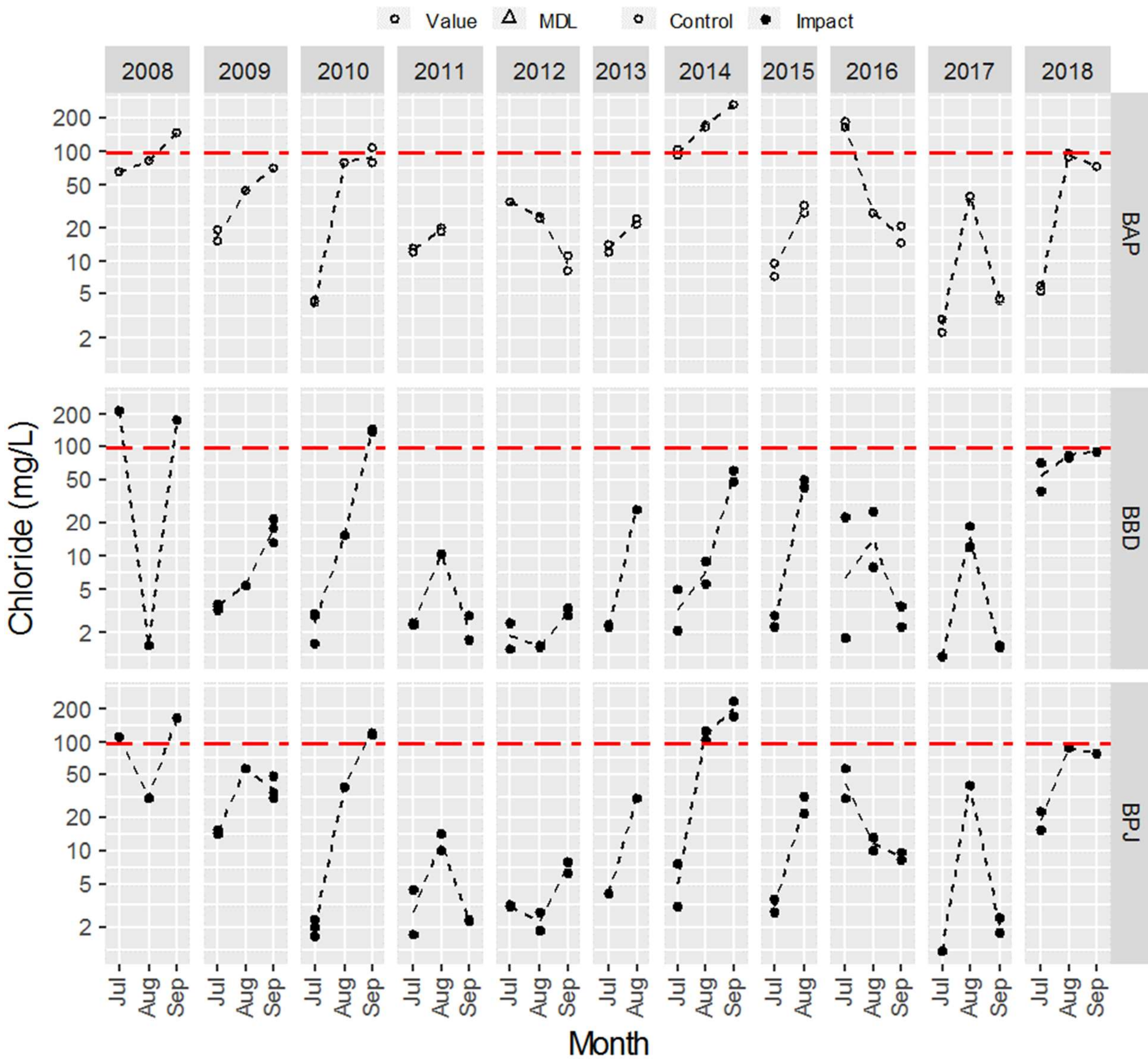


Figure 6-15. Nitrate –N (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

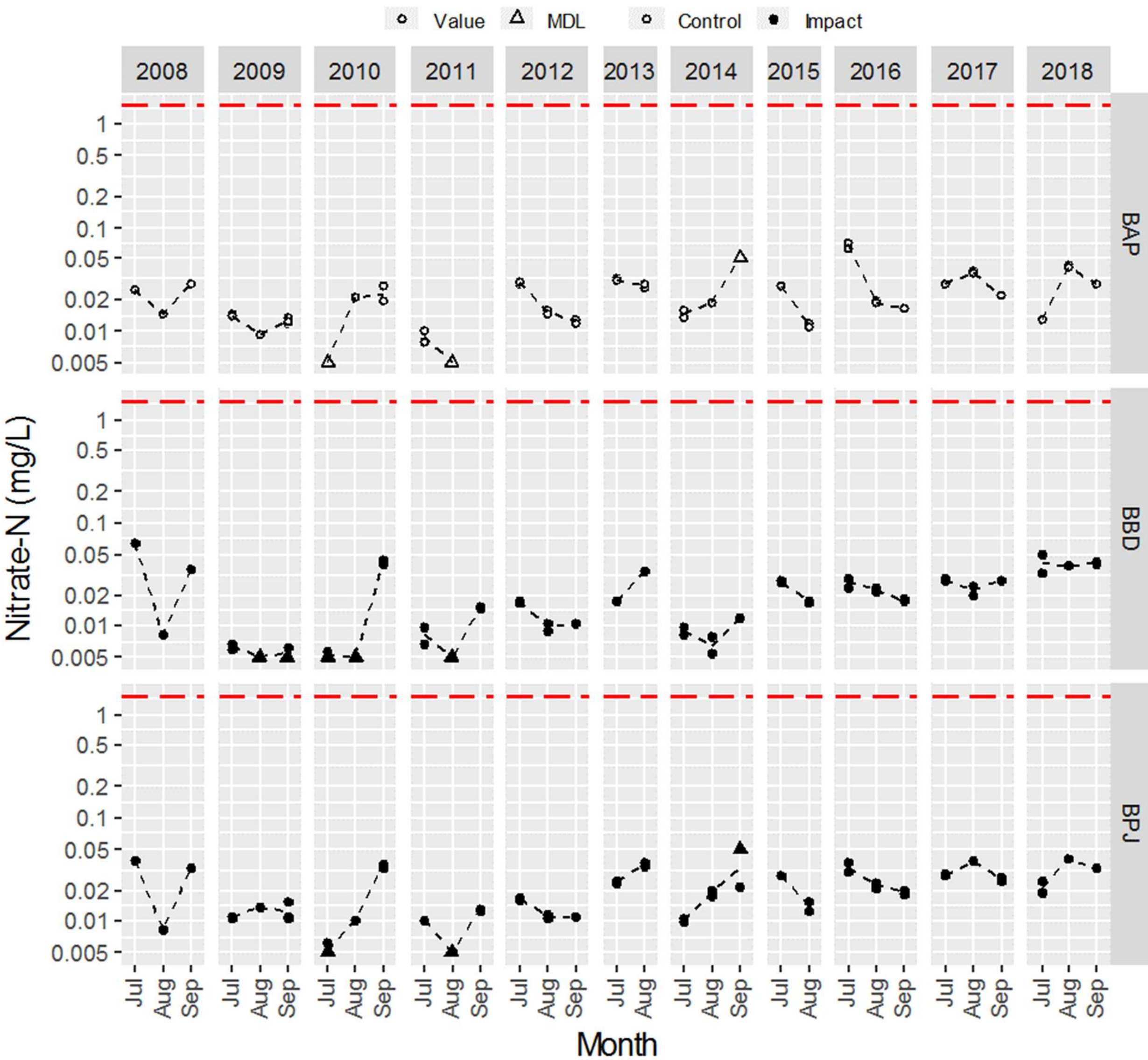


Figure 6-16. Total Kjeldahl Nitrogen (TKN; mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

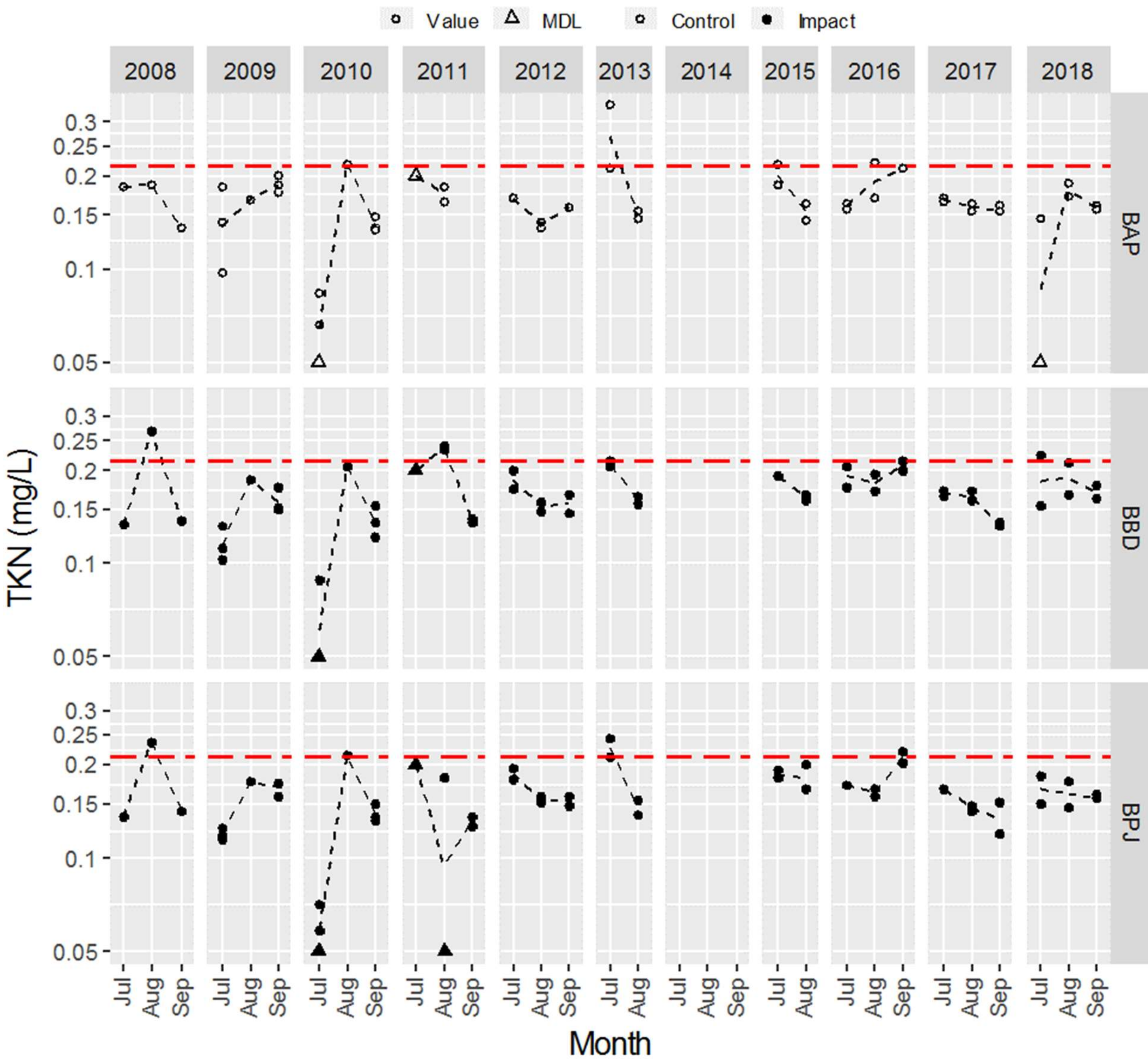


Figure 6-17. Total phosphorous (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

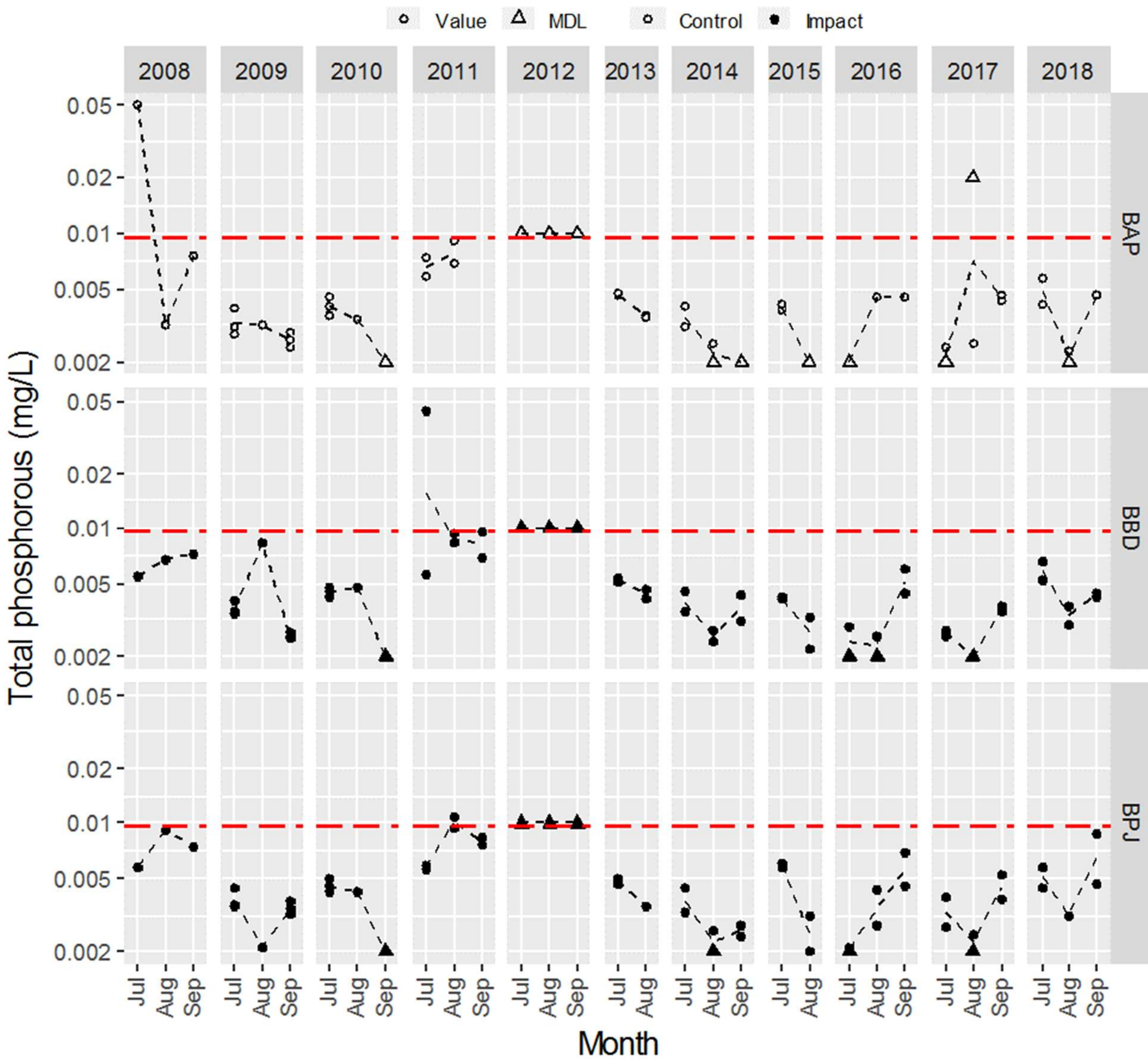


Figure 6-18. Ortho-phosphate (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

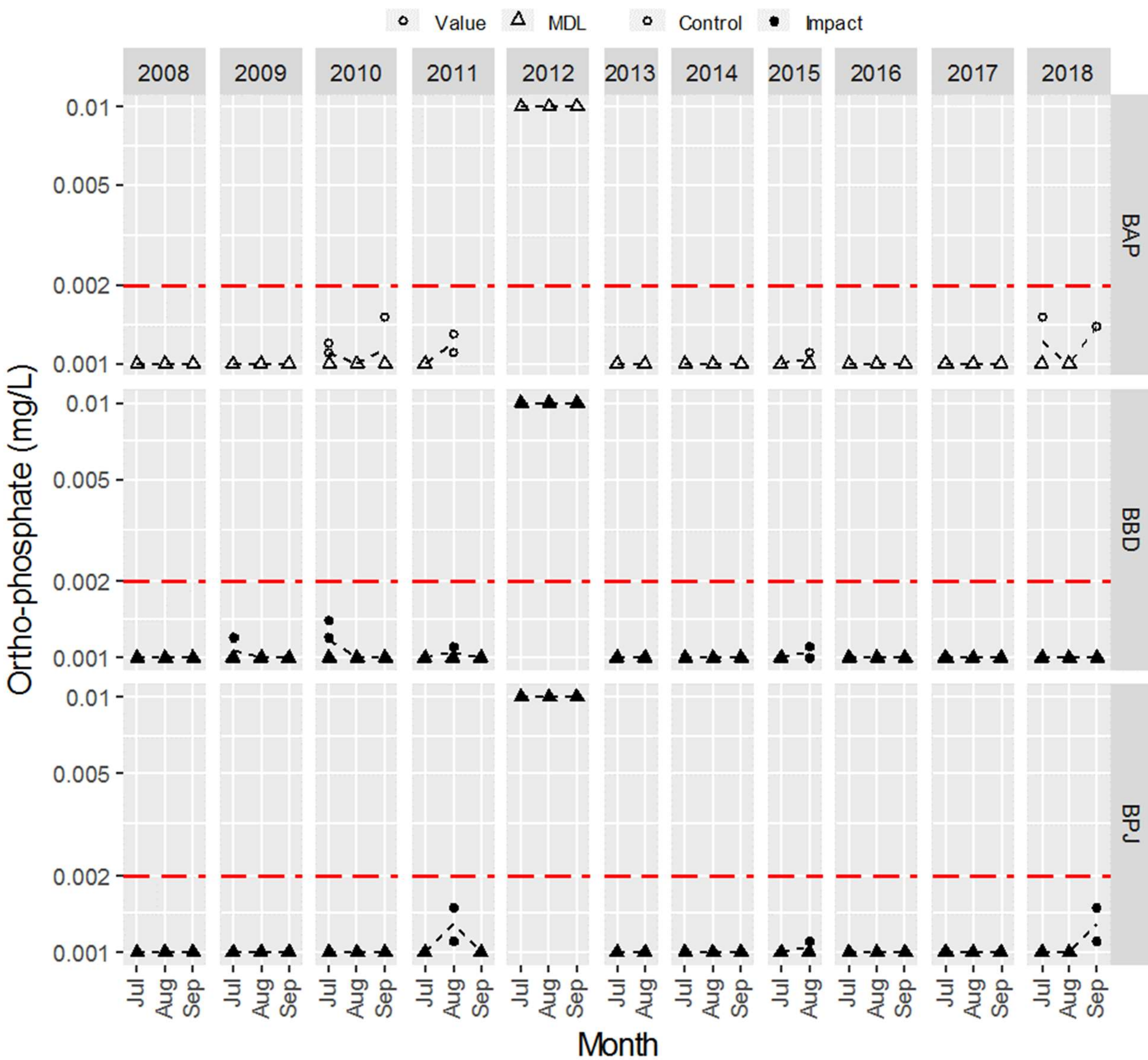


Figure 6-19. Reactive silica (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

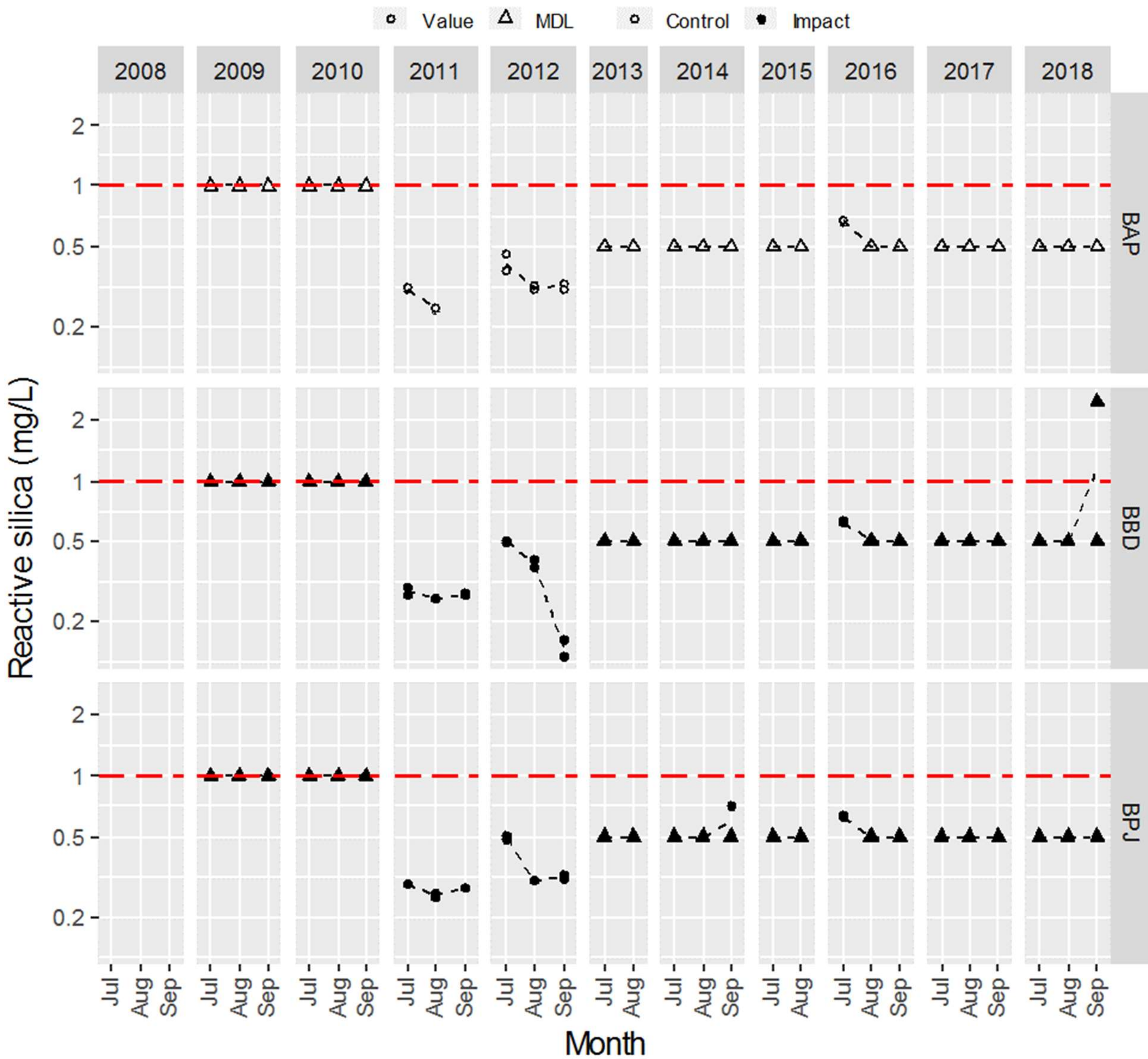


Figure 6-20. Sulphate (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

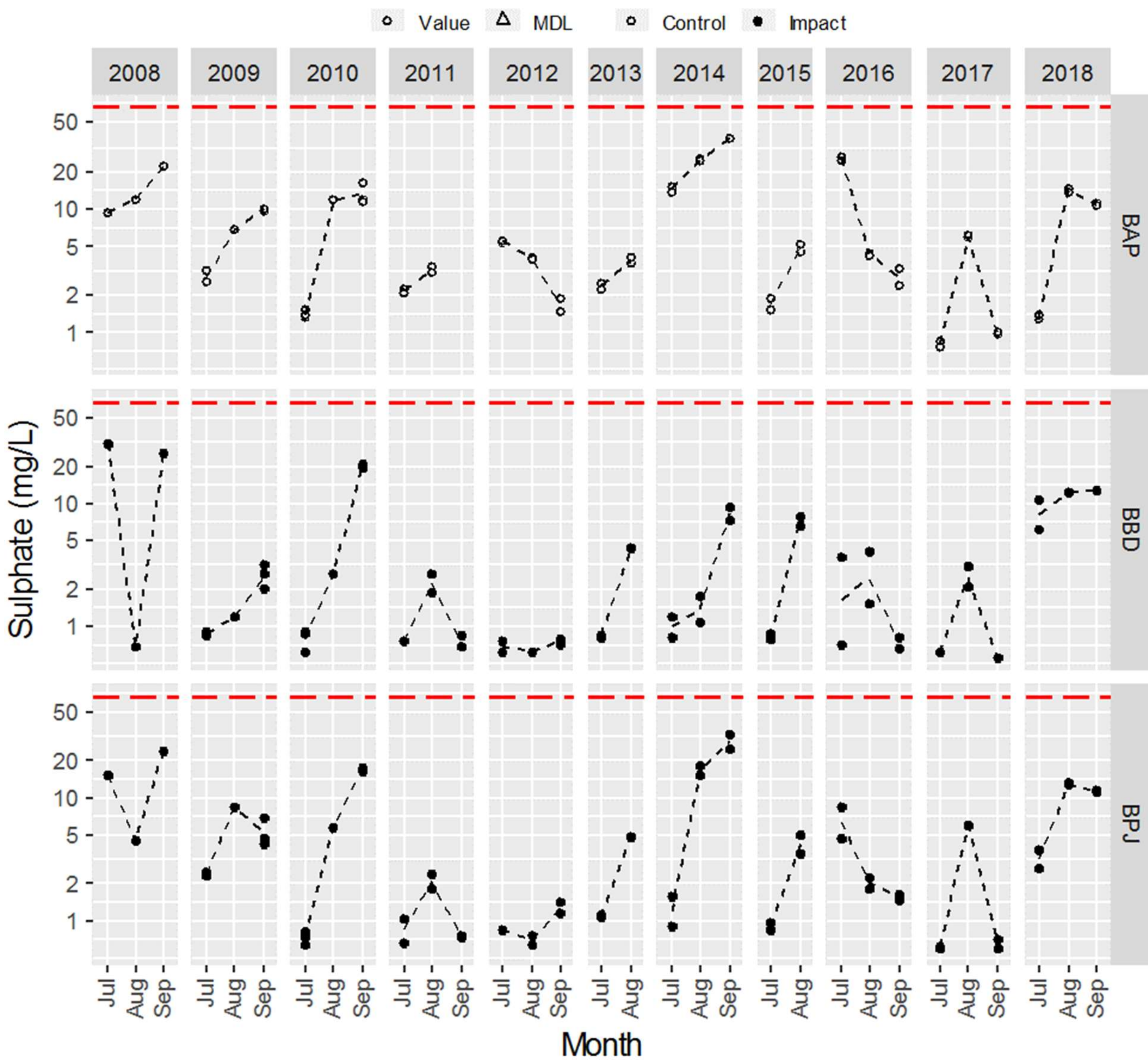


Figure 6-21. Dissolved Organic Carbon (DOC; mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

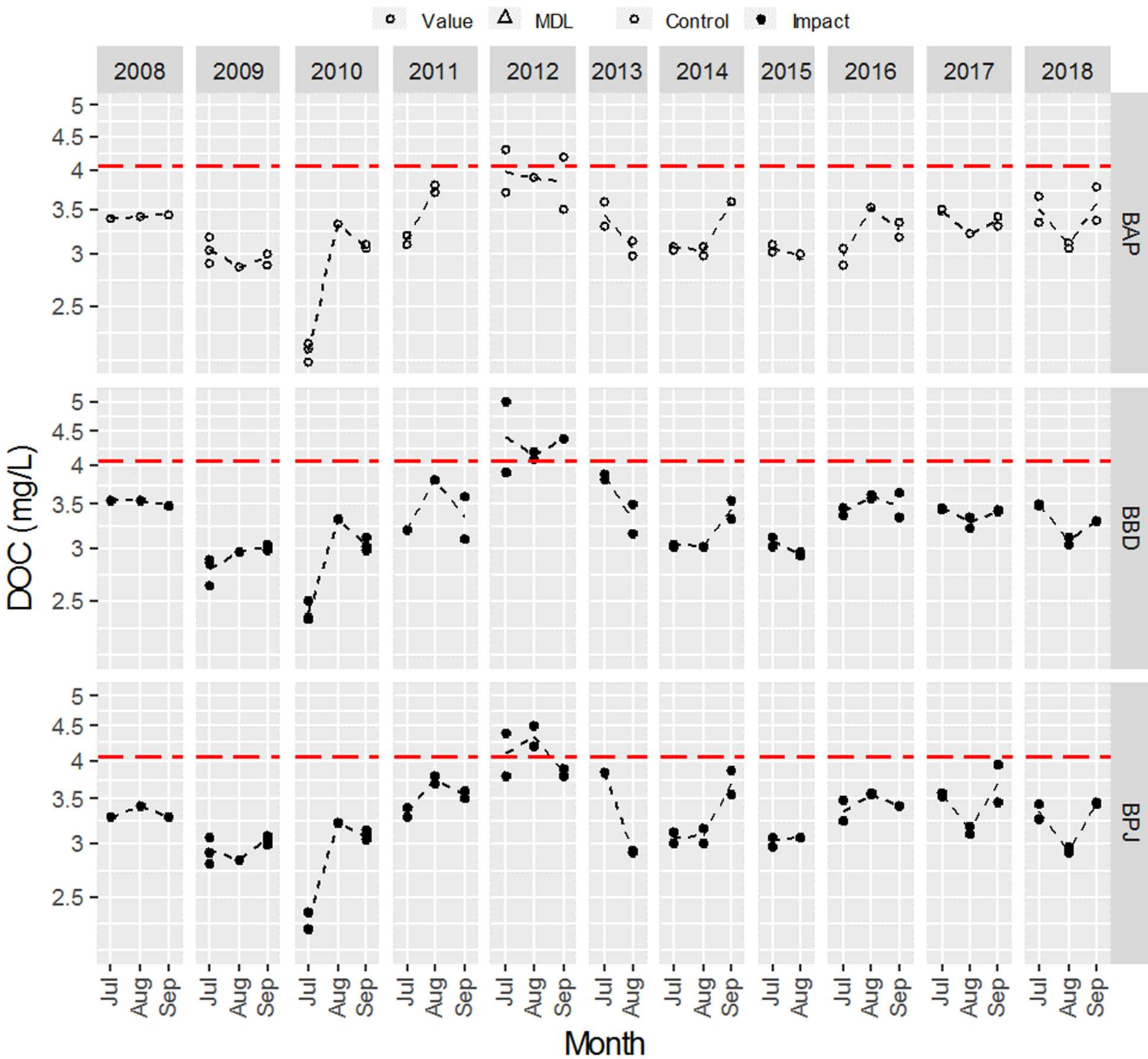


Figure 6-22. Total Organic Carbon (TOC; mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

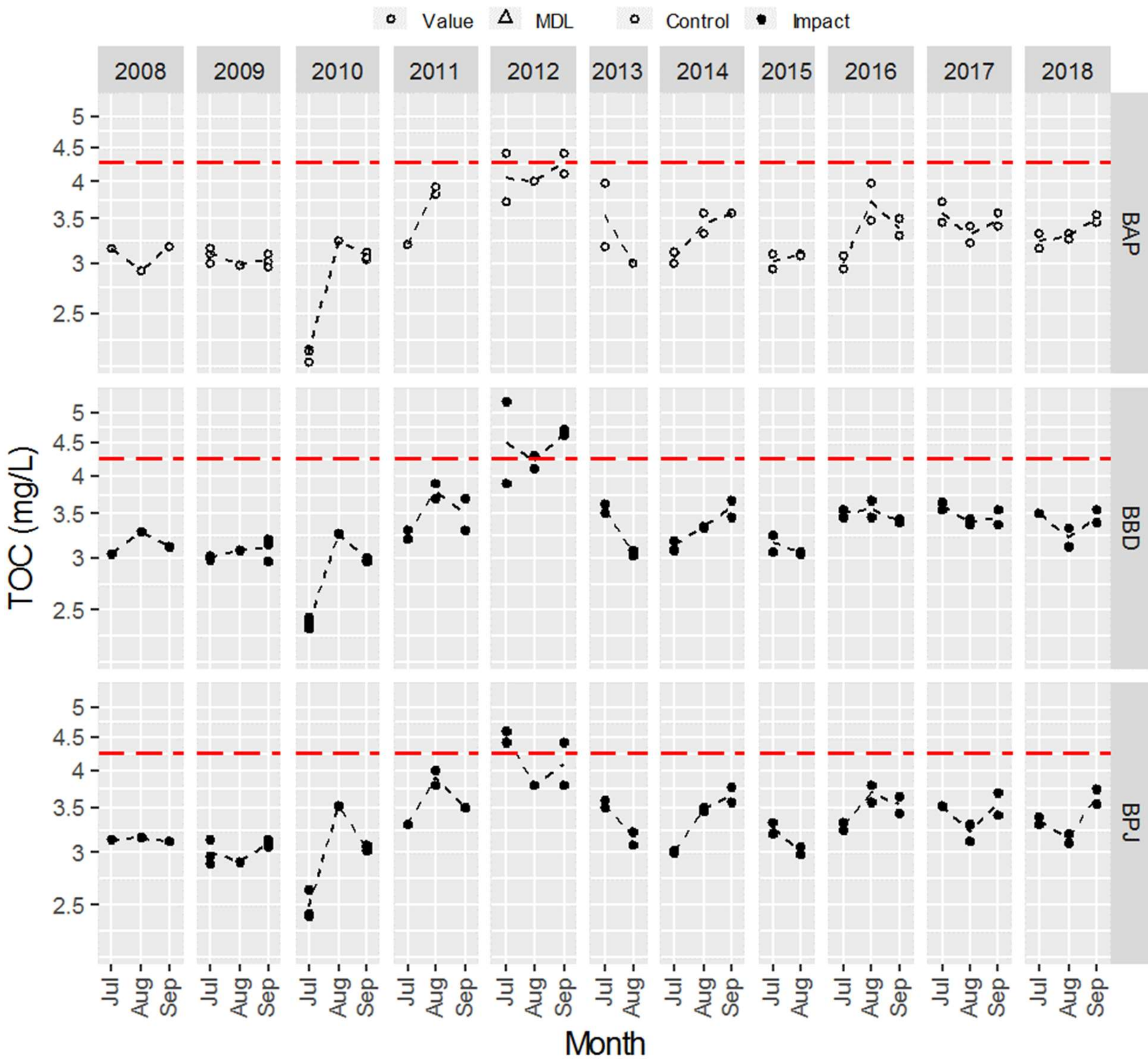


Figure 6-23. Total Aluminum (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

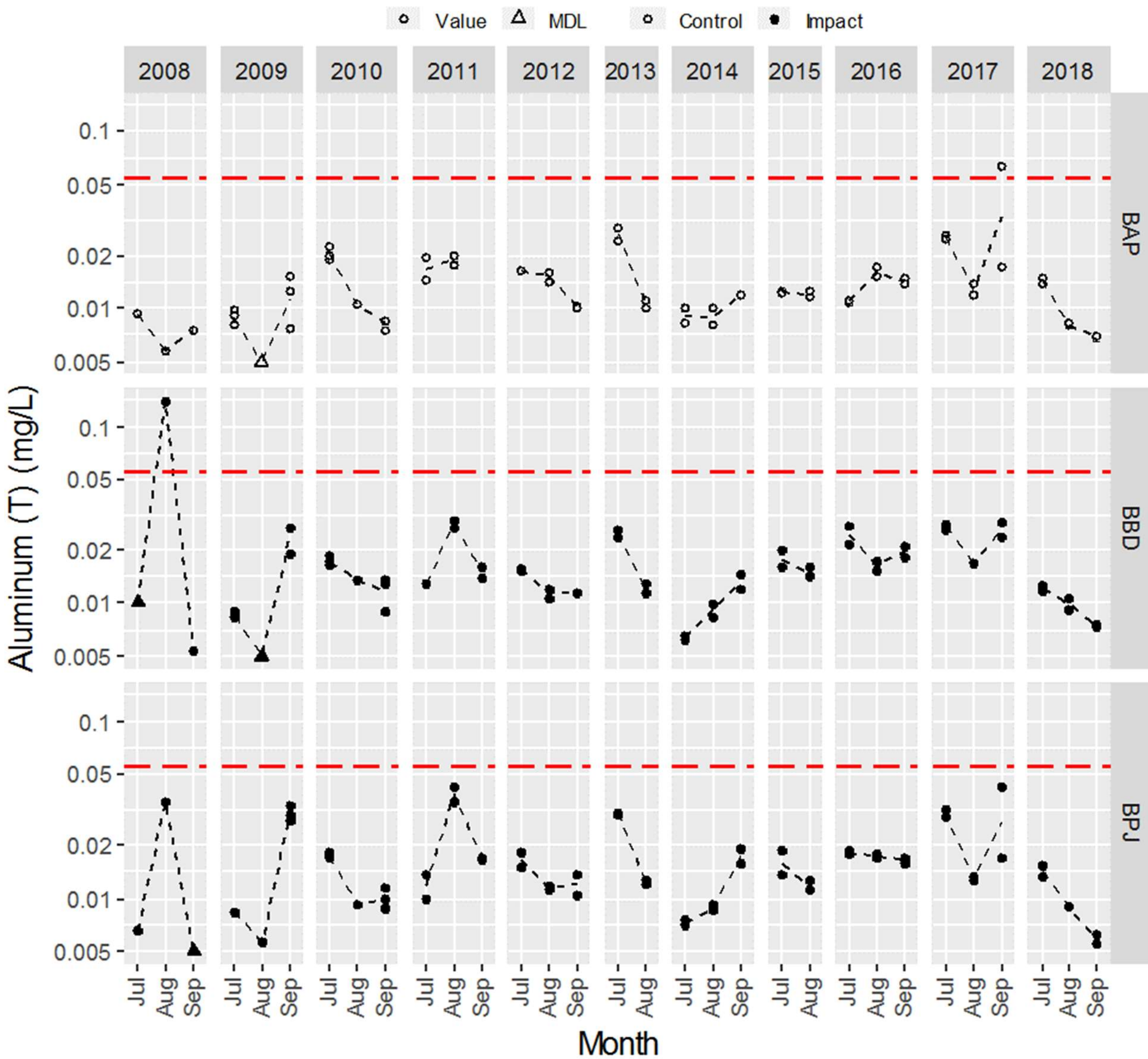


Figure 6-24. Total arsenic (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

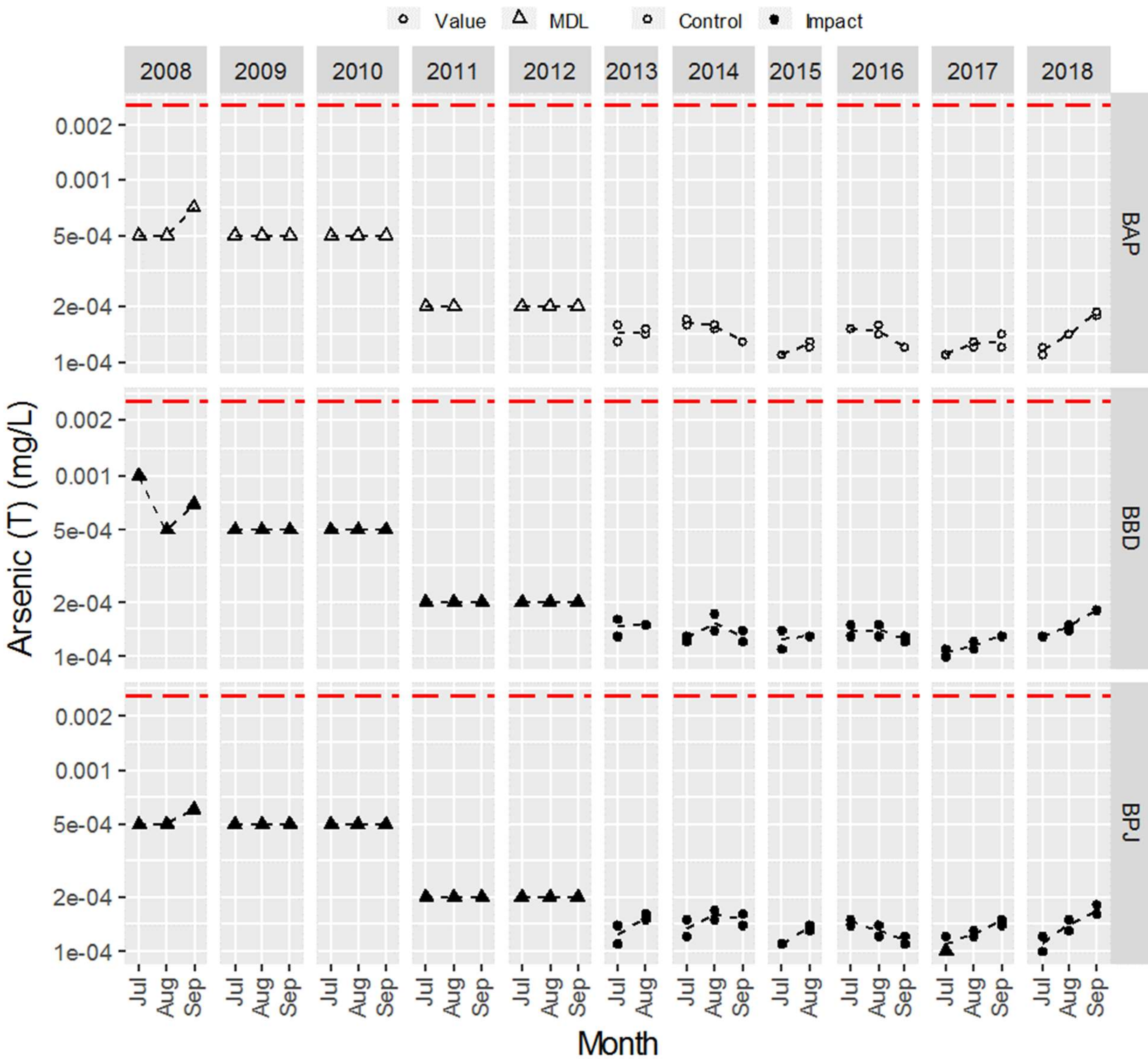


Figure 6-25. Total barium (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

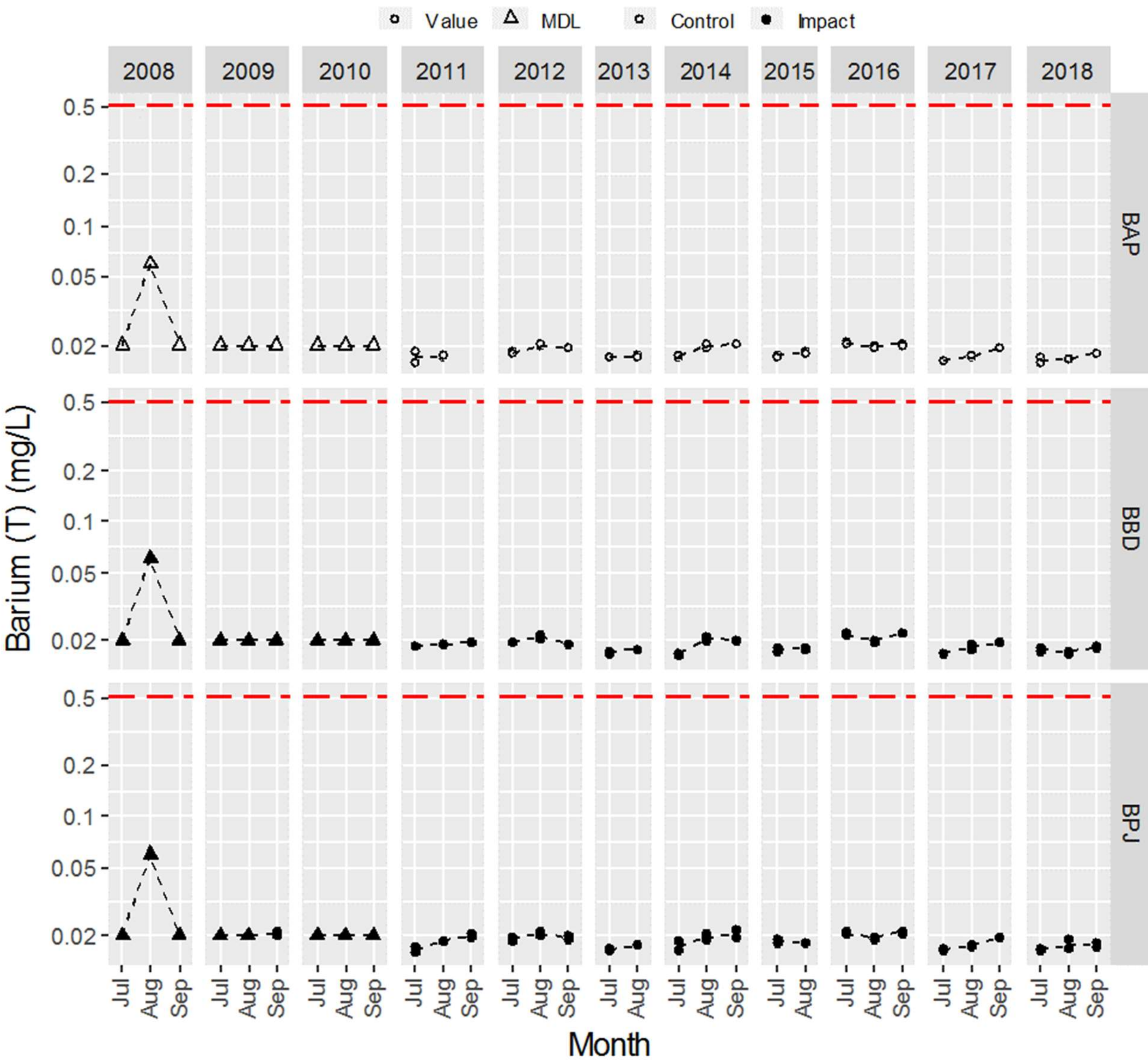


Figure 6-26. Total boron (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

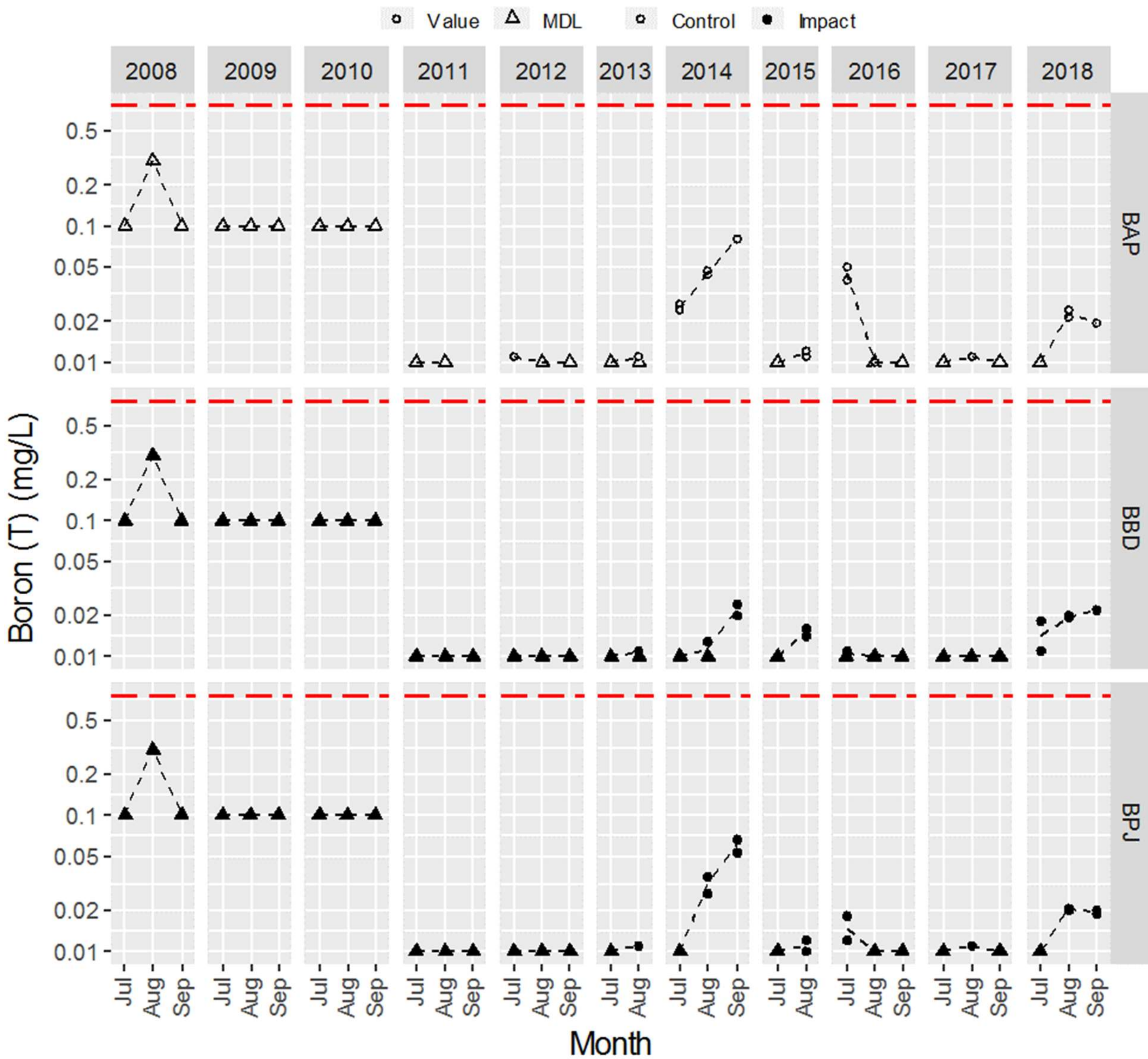


Figure 6-27. Total calcium (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

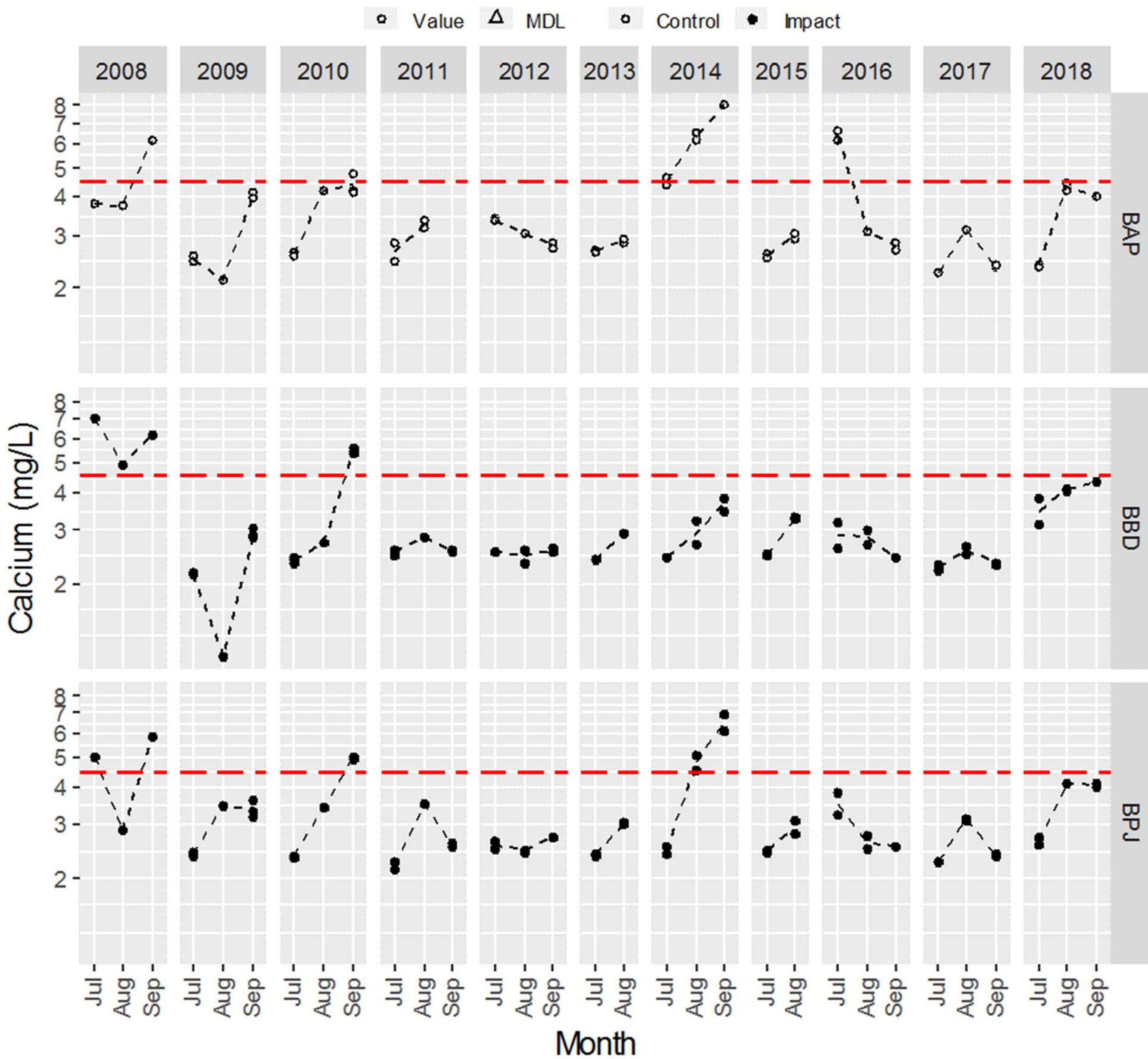


Figure 6-28. Total chromium (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

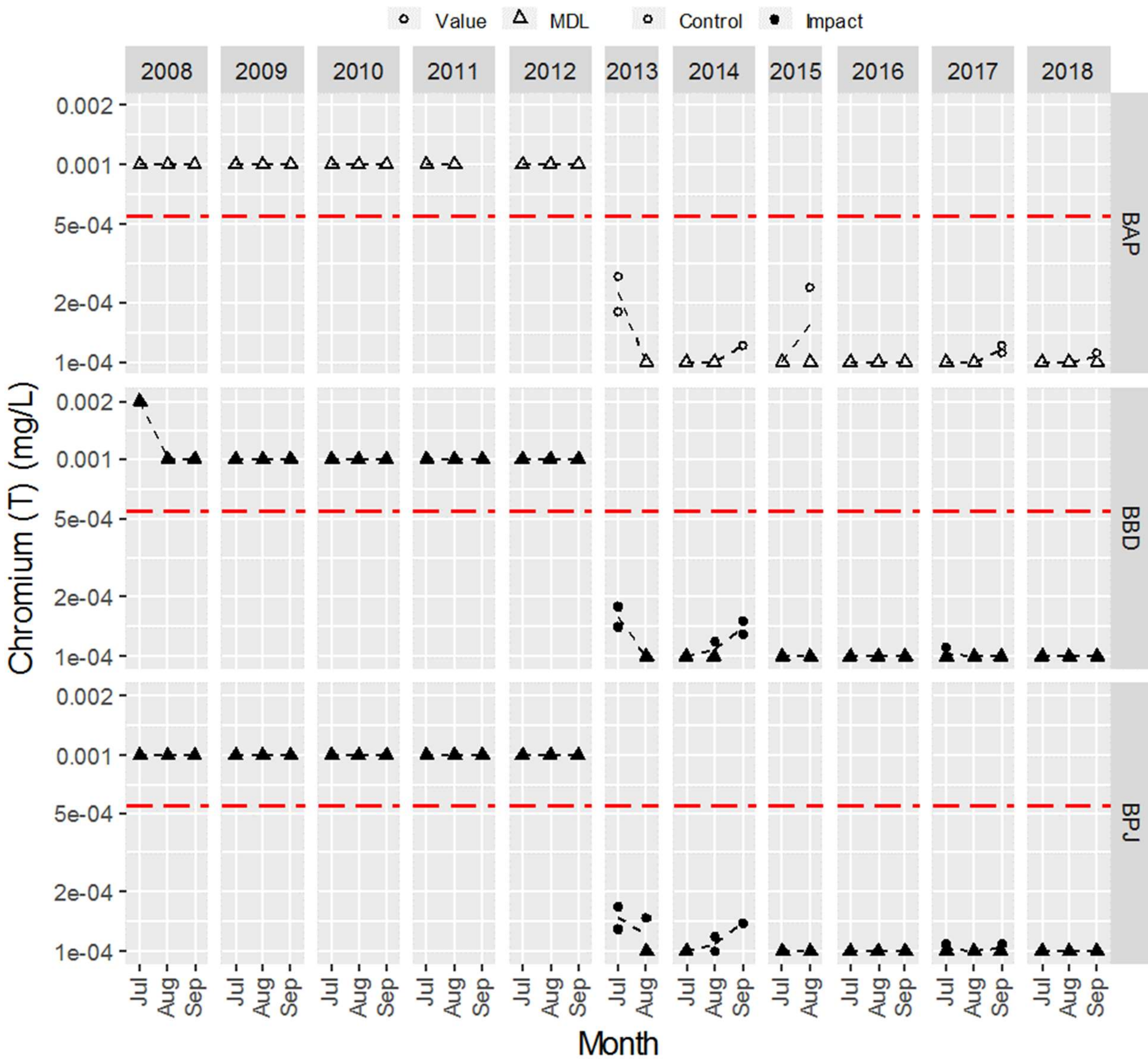


Figure 6-29. Total copper (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

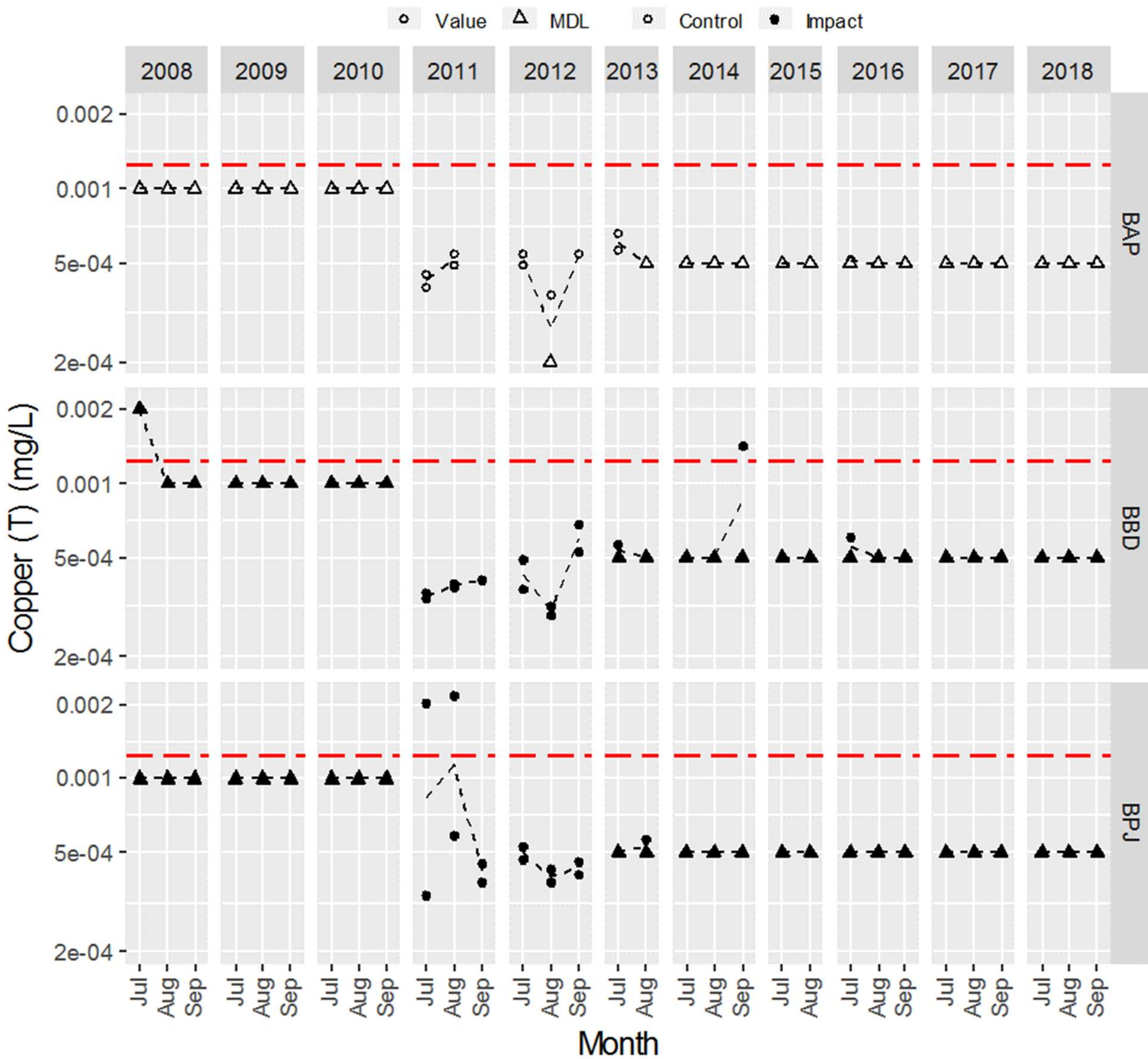


Figure 6-30. Total iron (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

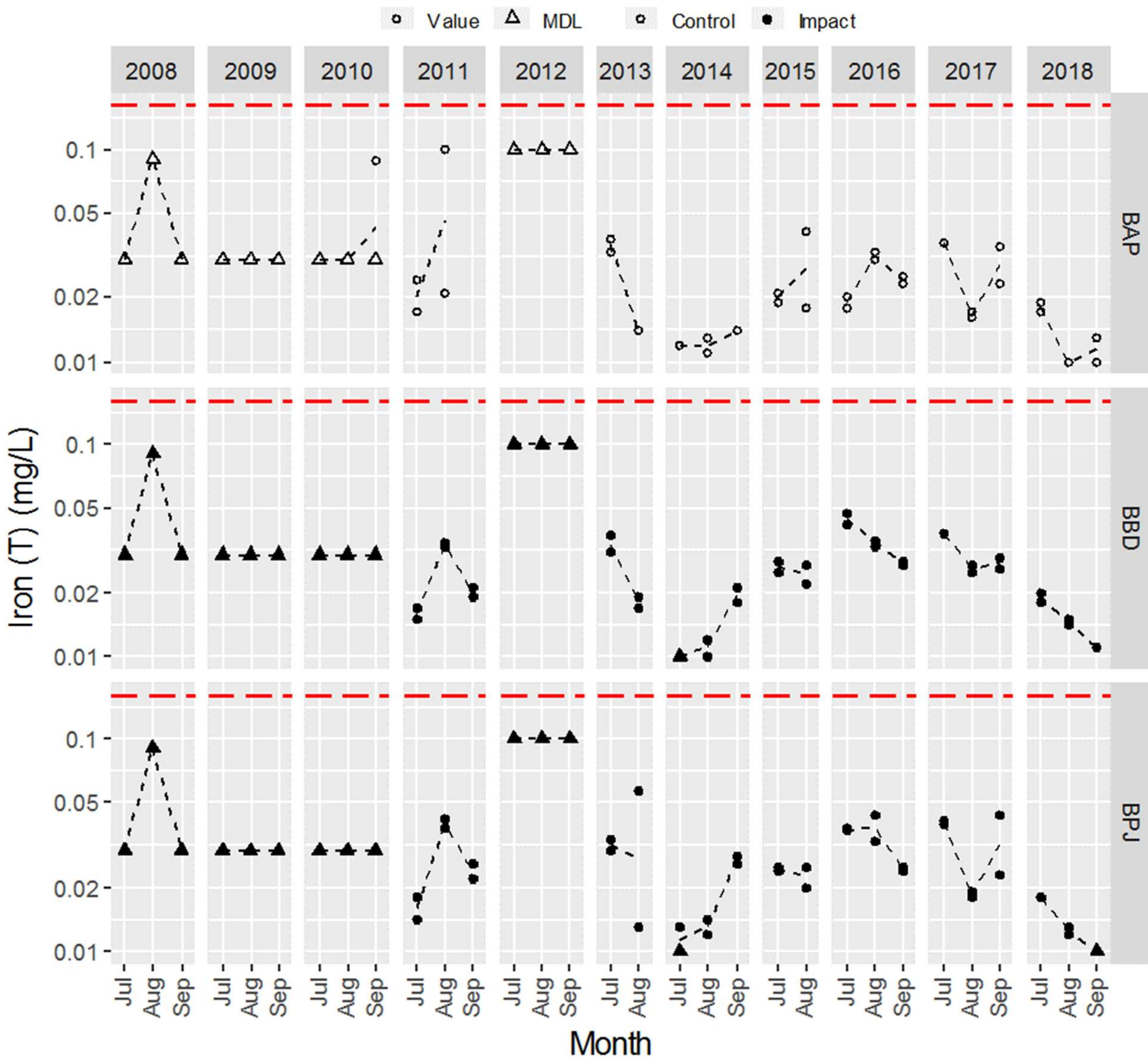


Figure 6-31. Total lithium (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

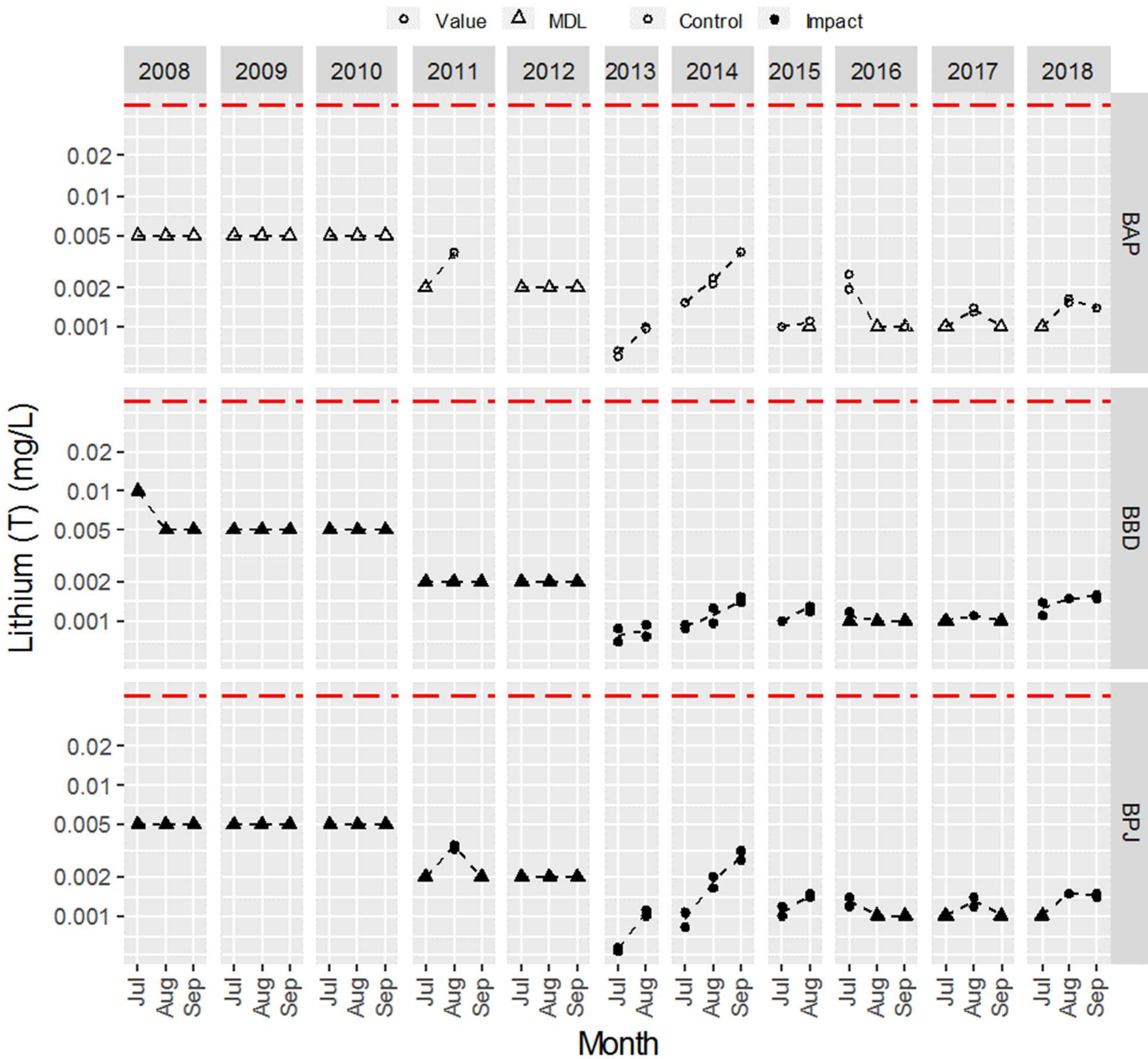


Figure 6-32. Total magnesium (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

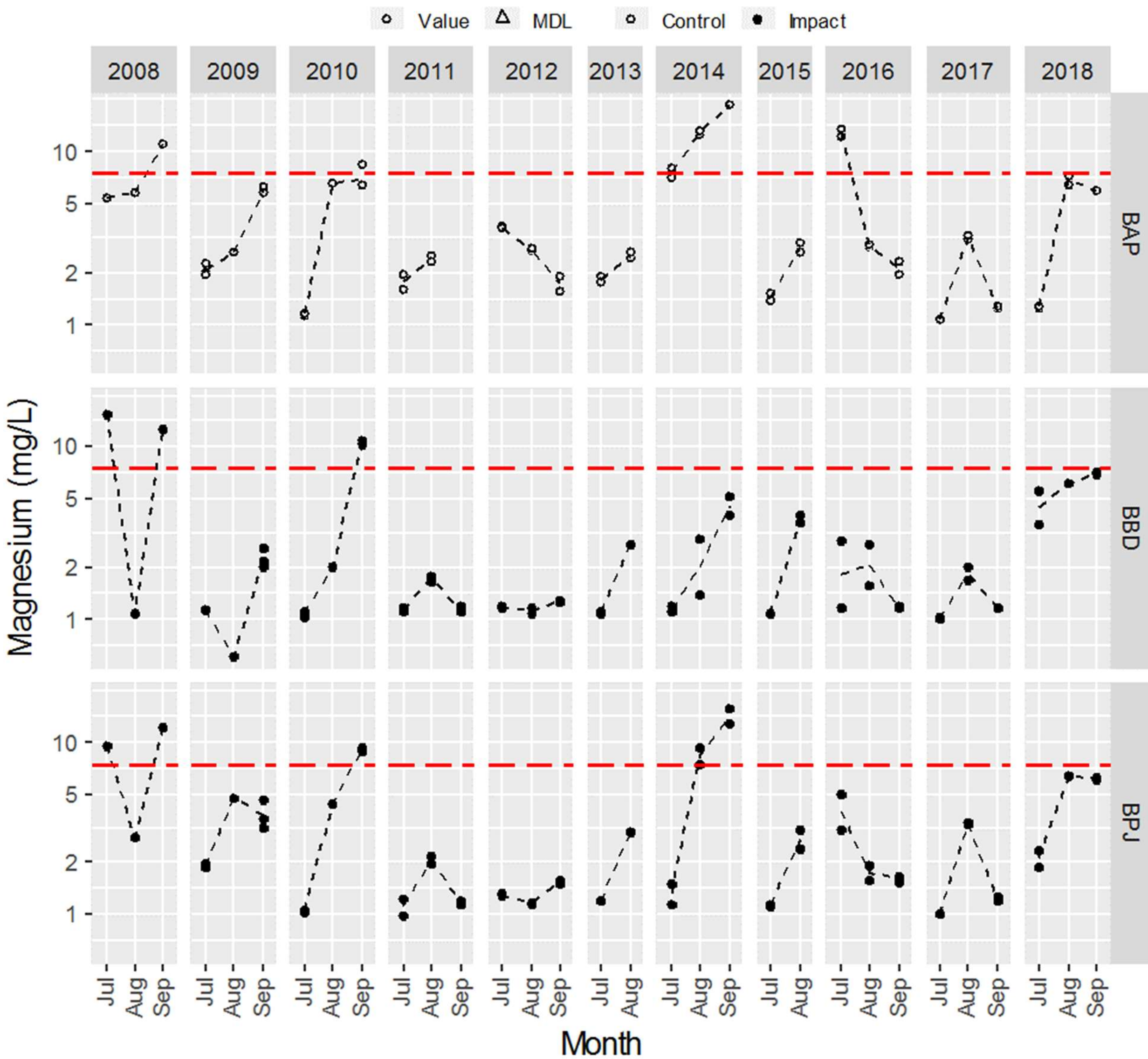


Figure 6-33. Total manganese (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

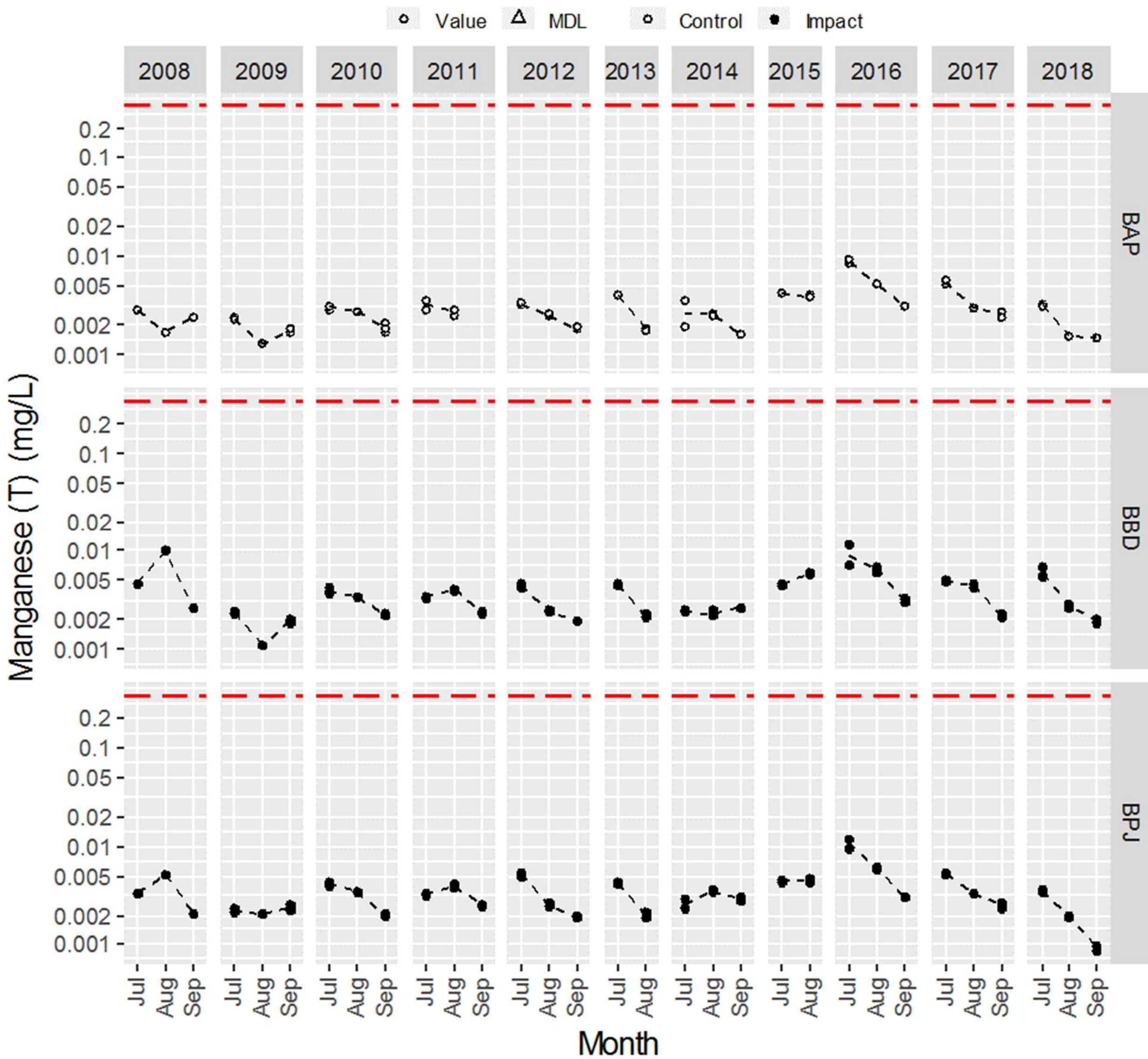


Figure 6-34. Total molybdenum (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

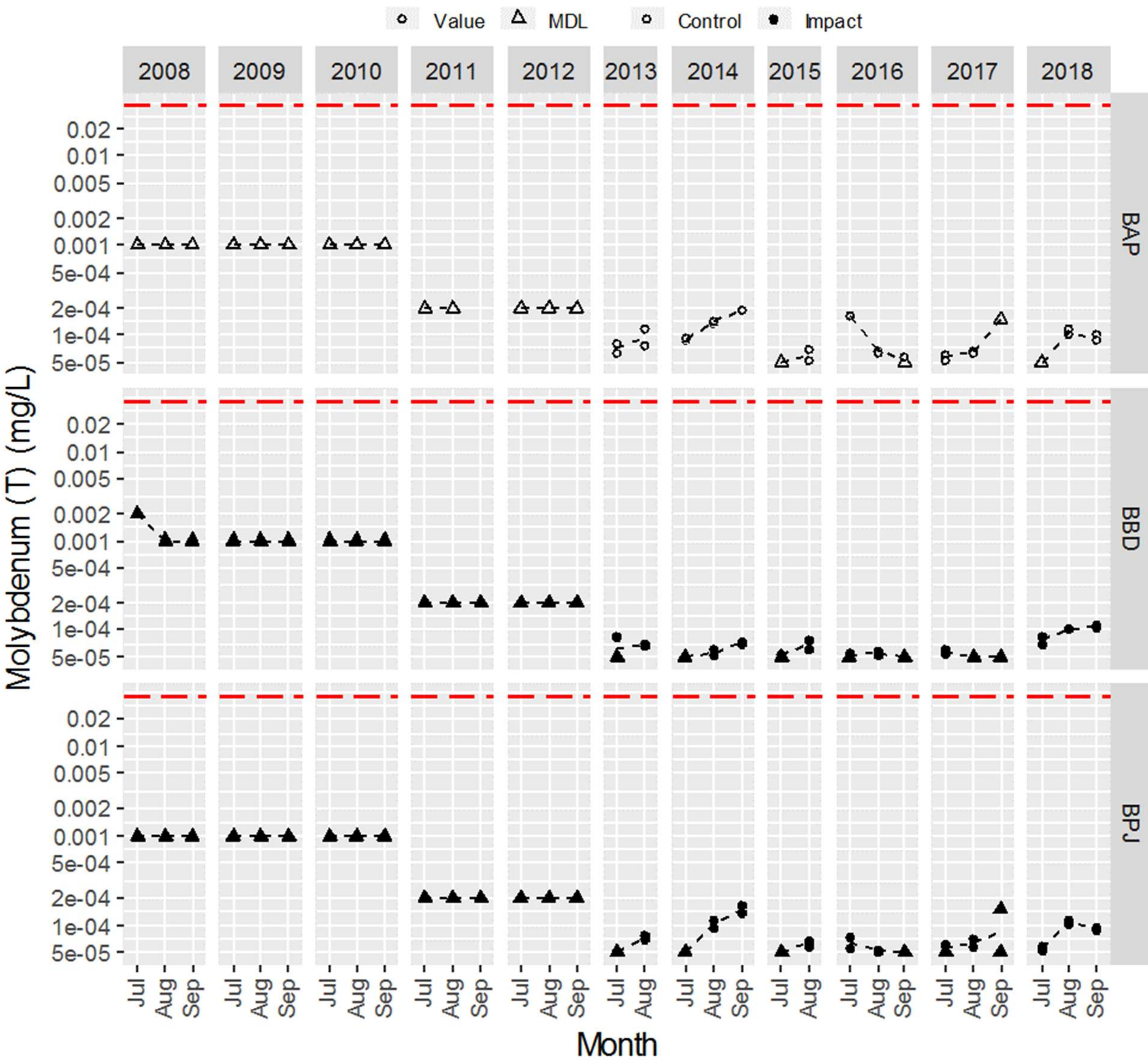


Figure 6-35. Total potassium (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

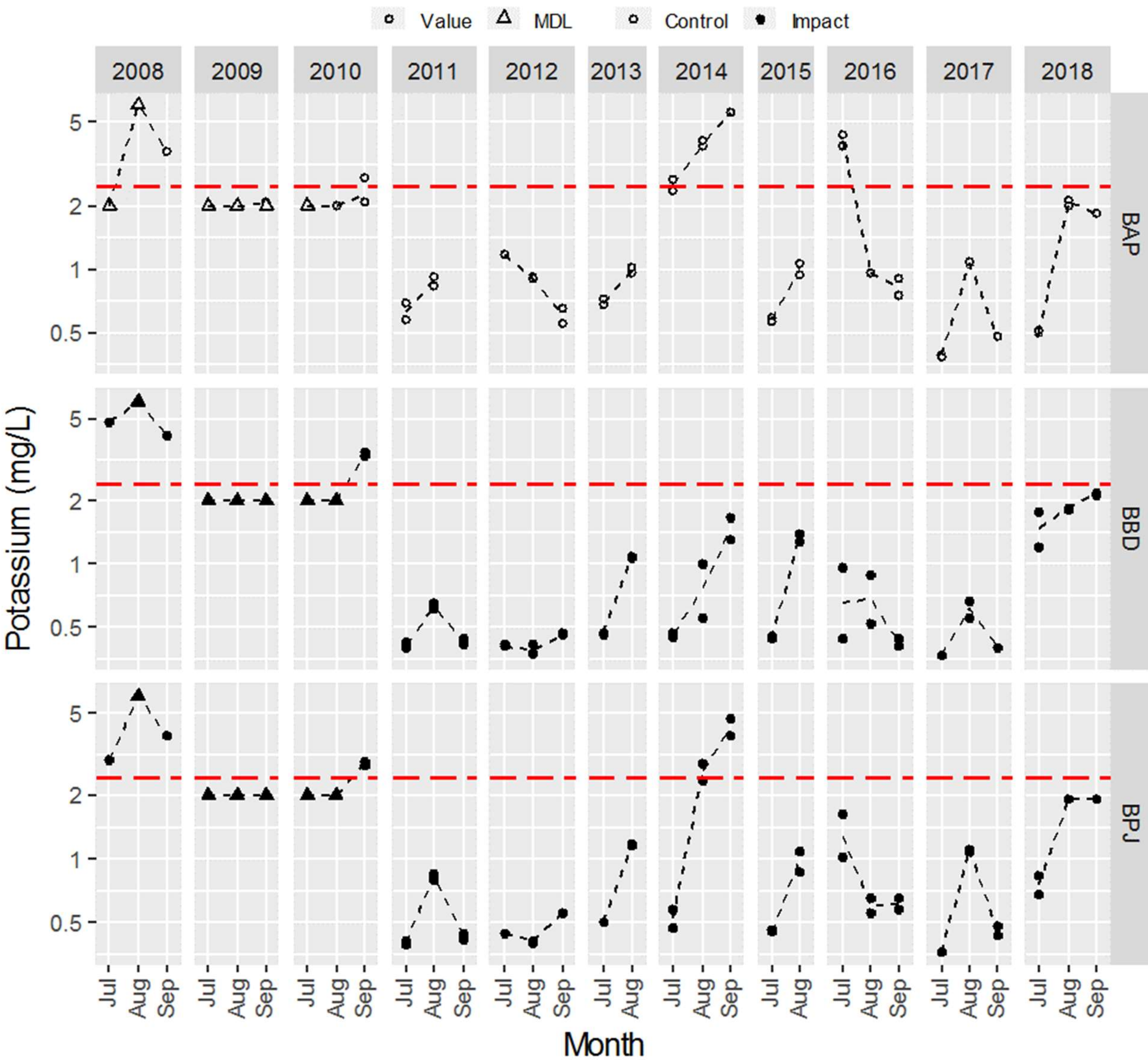


Figure 6-36. Total sodium (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

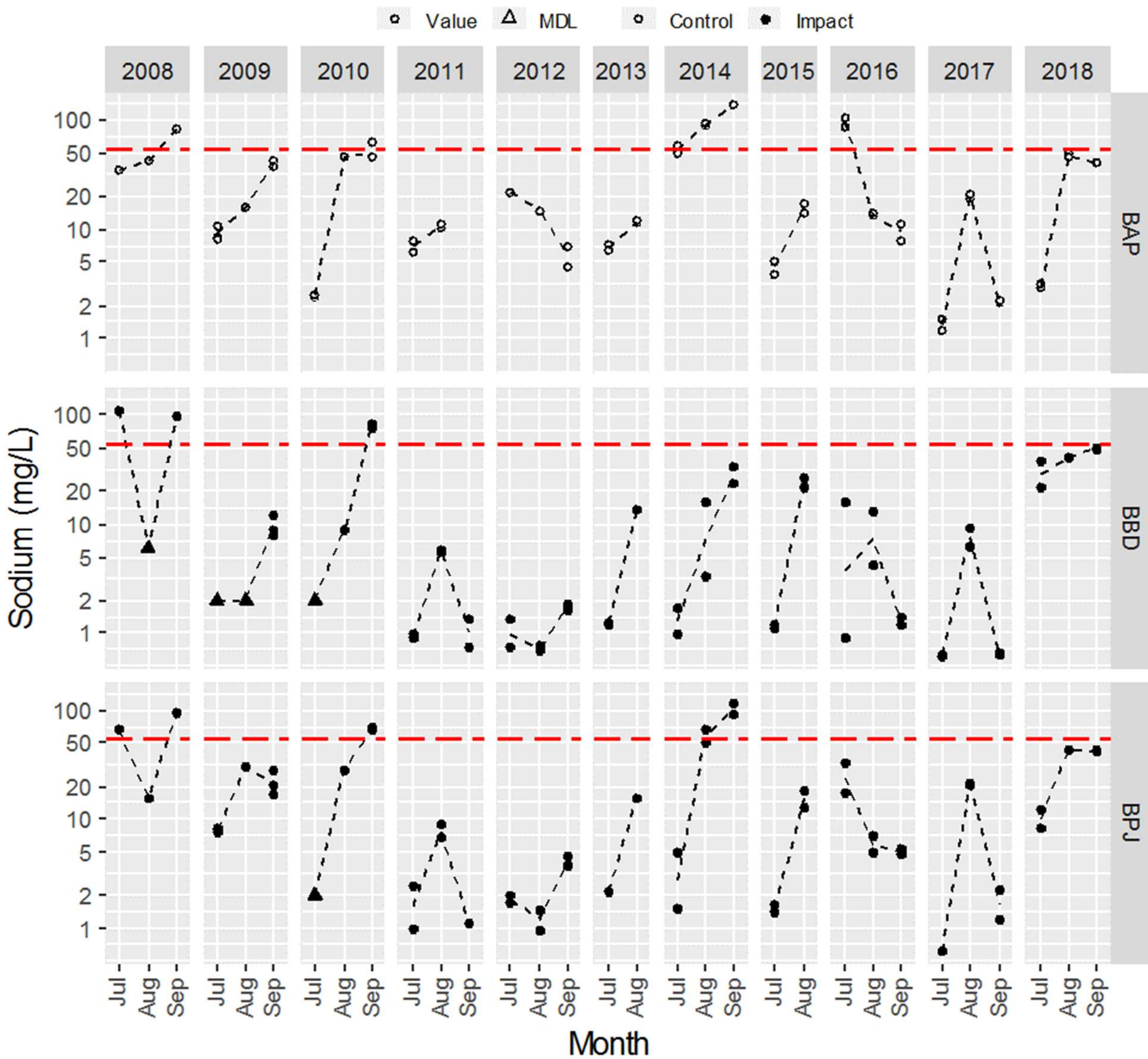


Figure 6-37. Total strontium (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

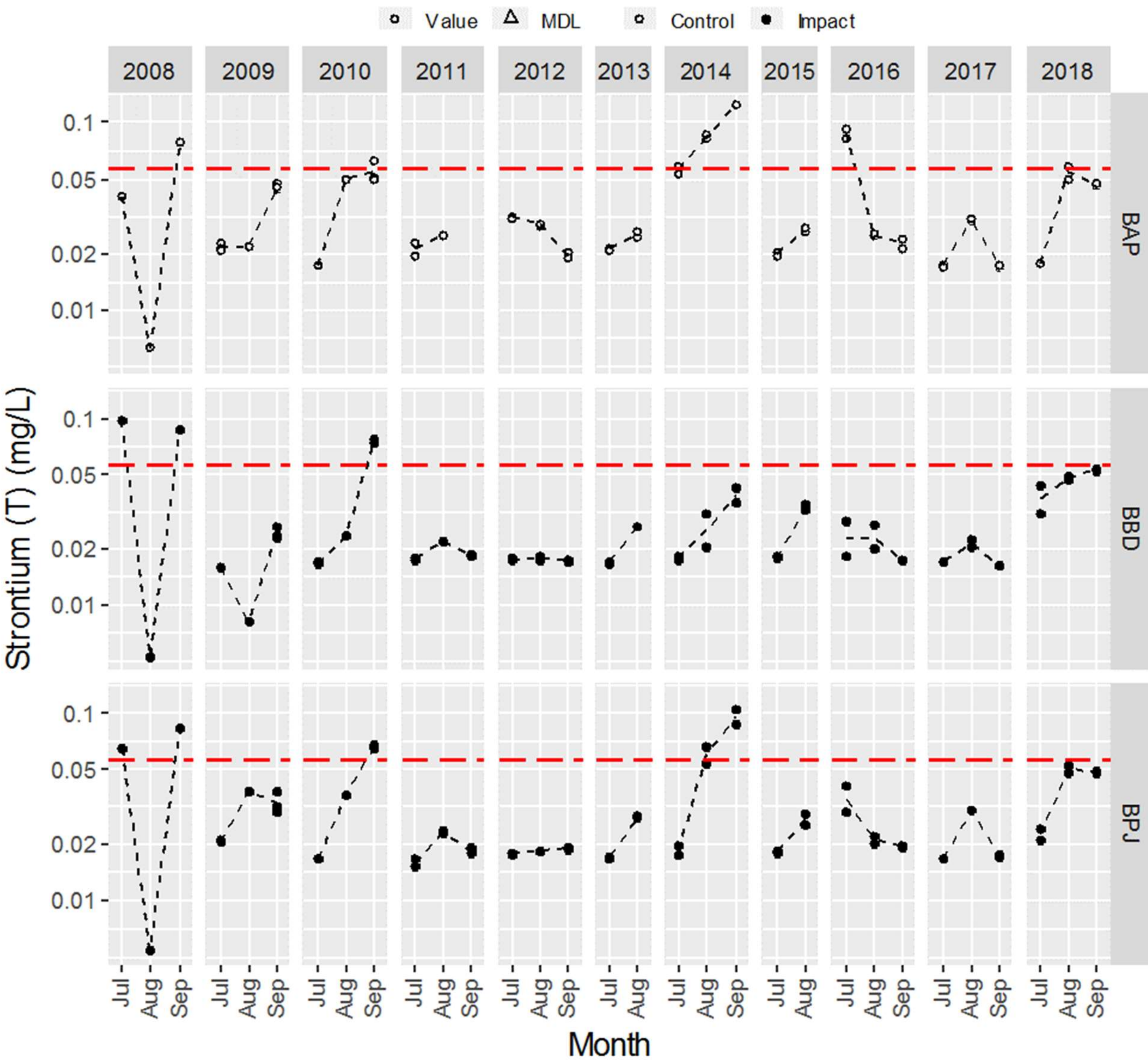


Figure 6-38. Total titanium (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

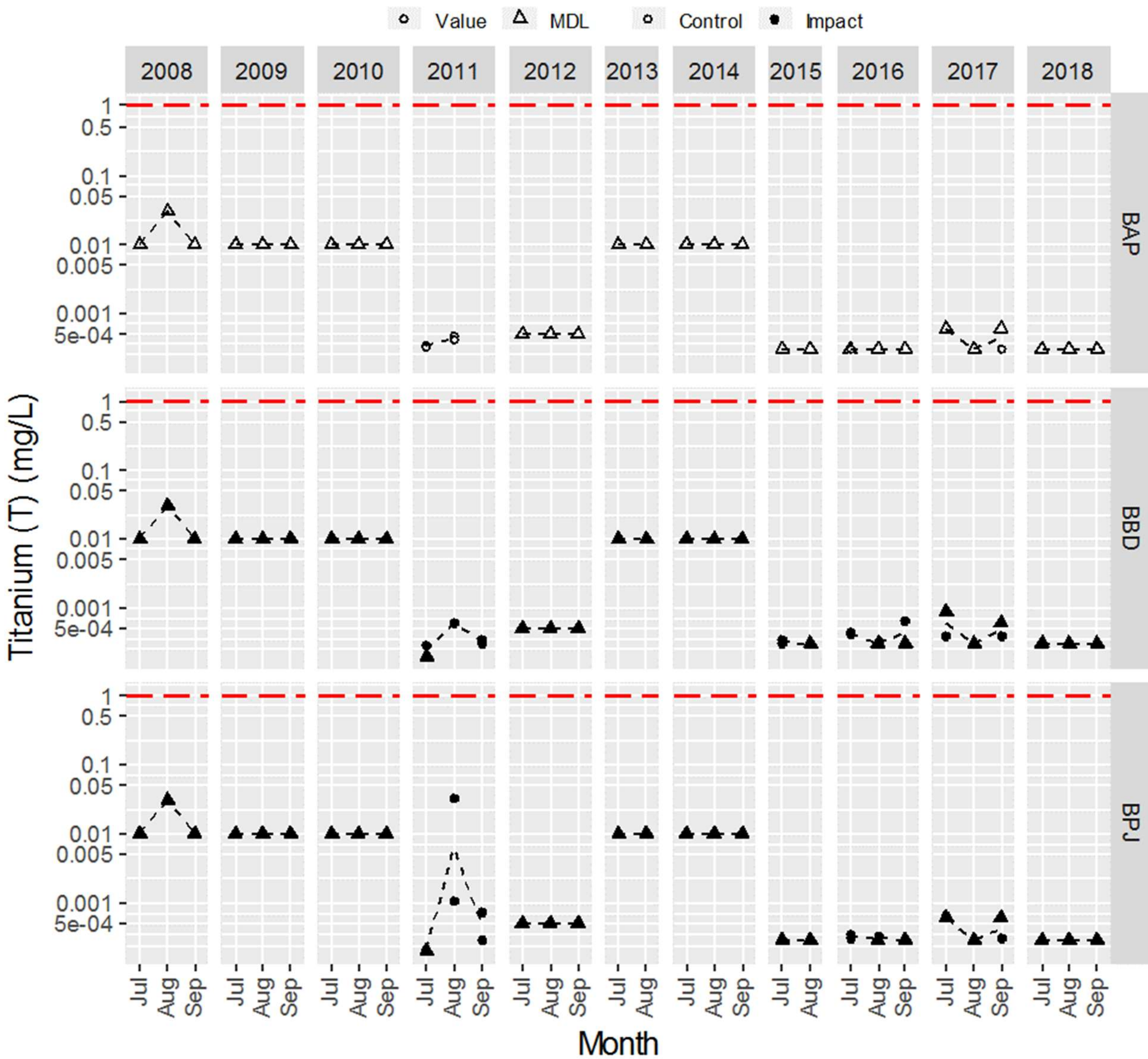


Figure 6-39. Total uranium (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

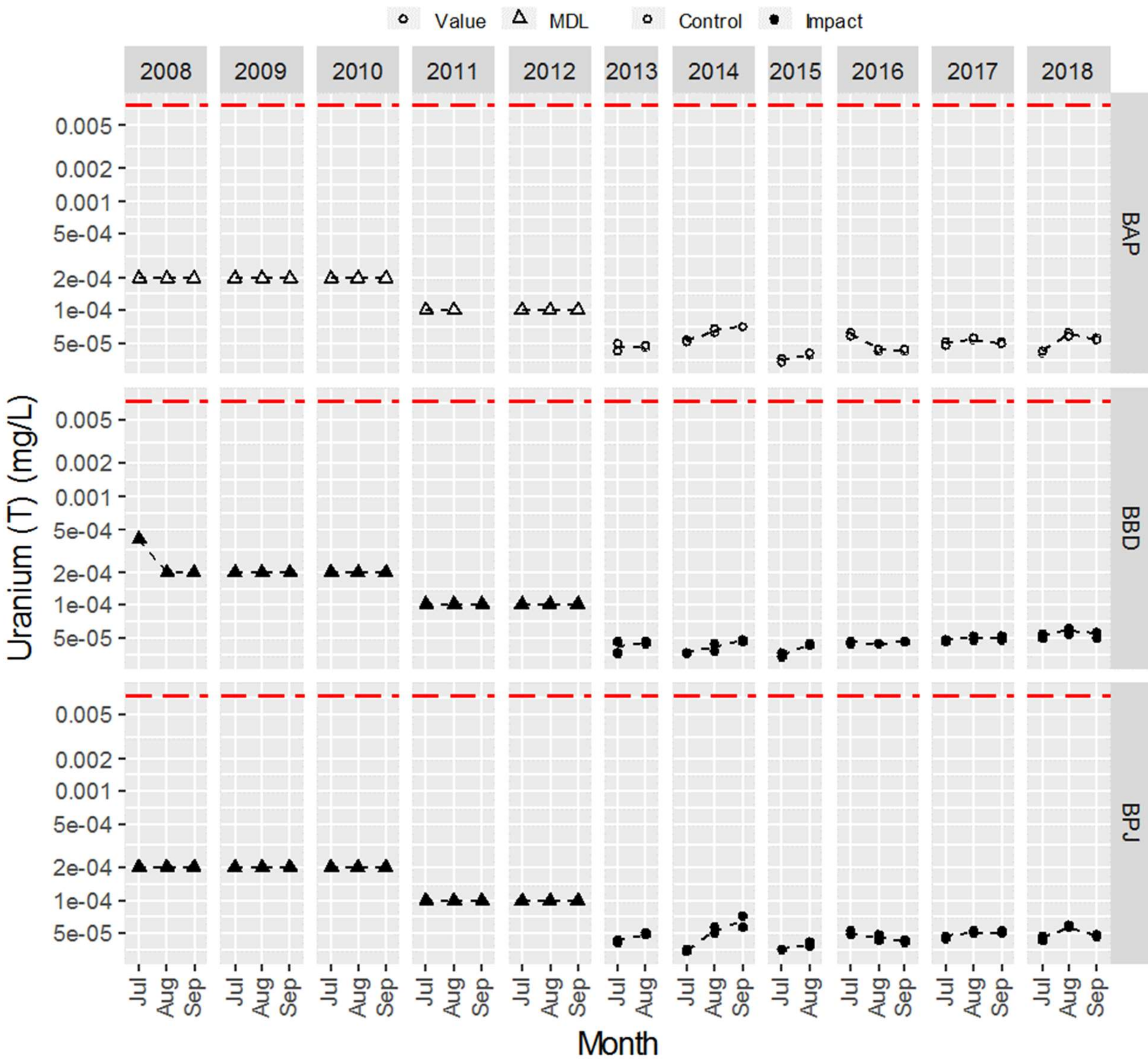


Figure 6-40. Dissolved aluminum (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

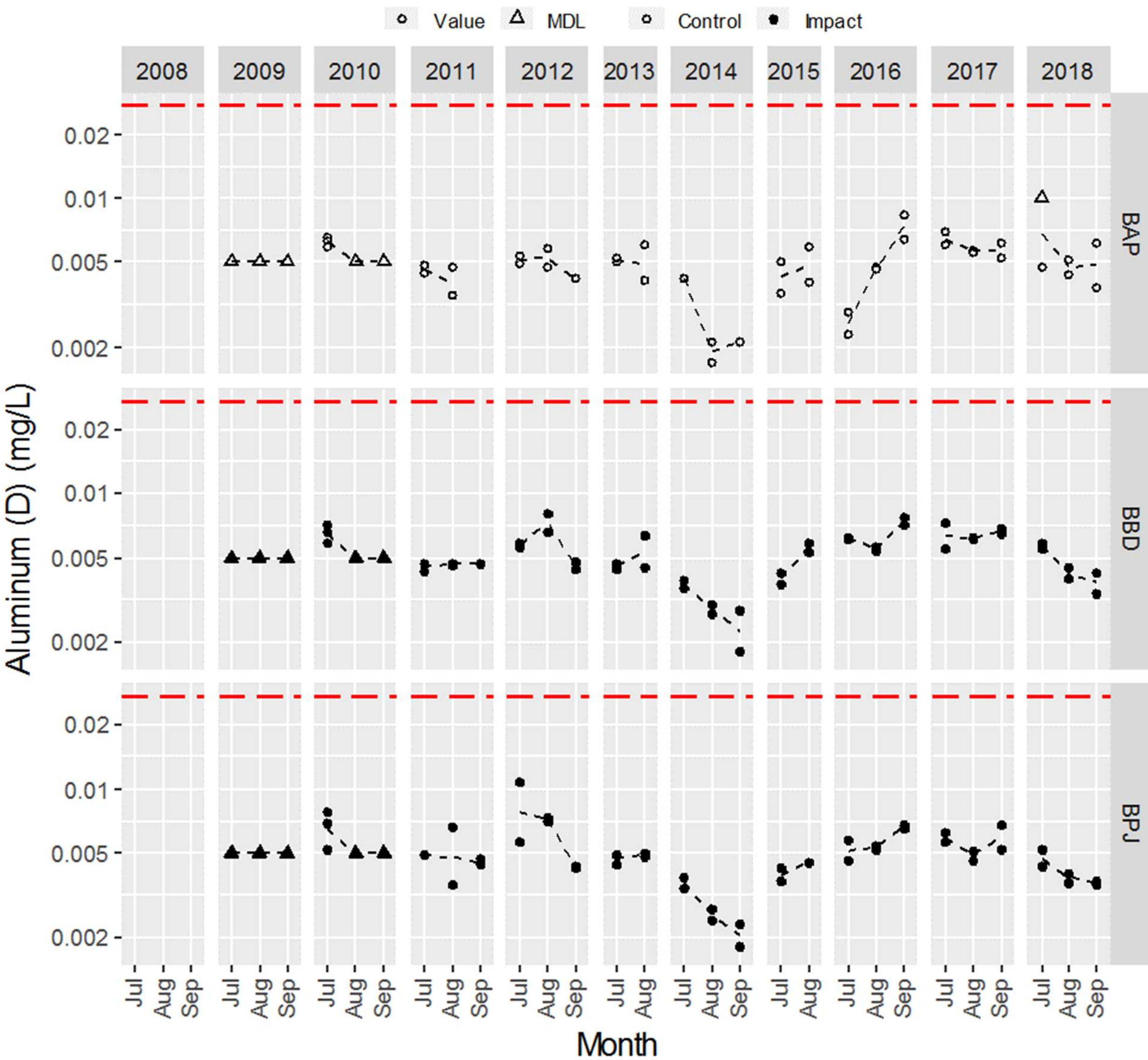


Figure 6-41. Dissolved arsenic (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

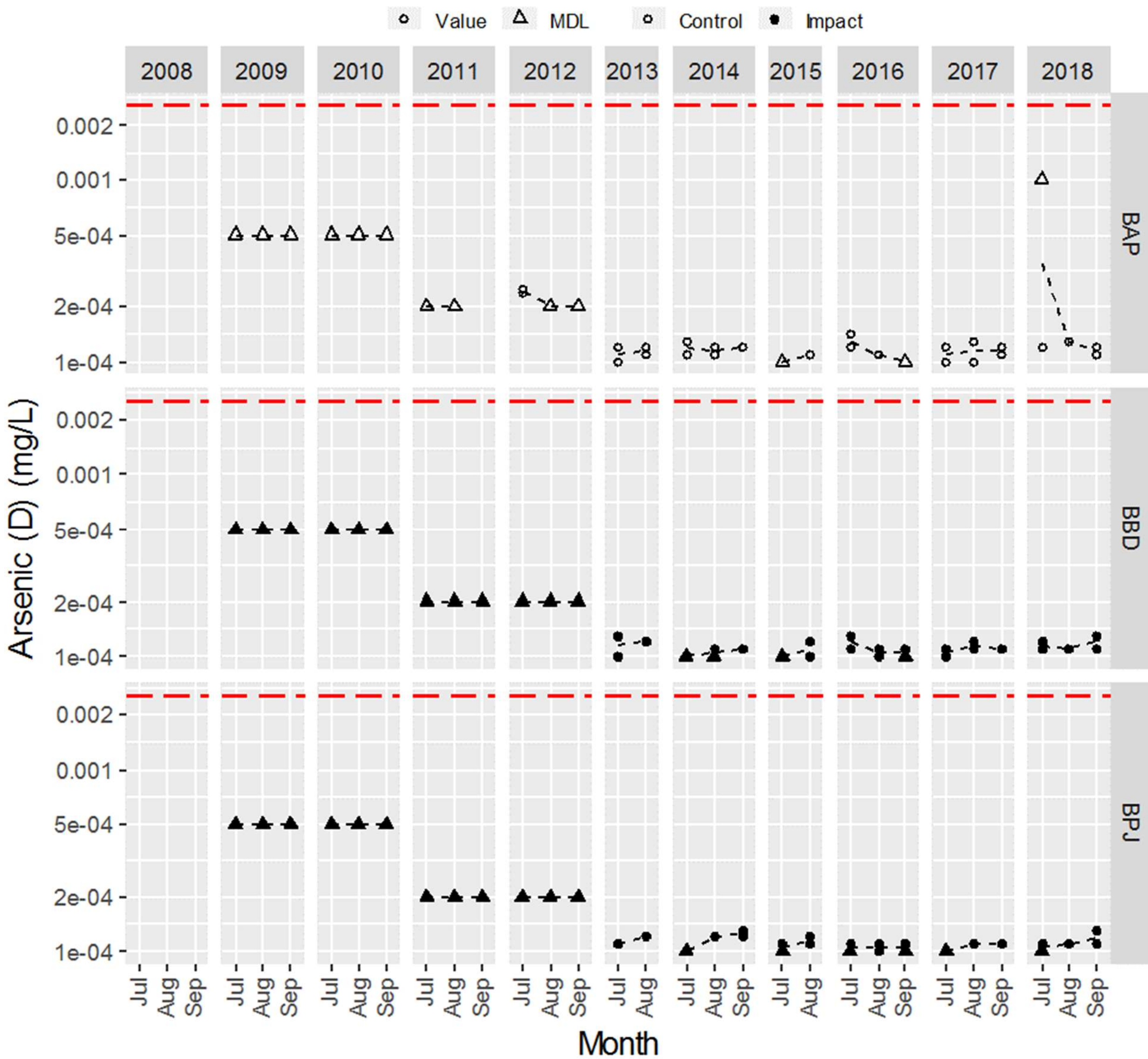


Figure 6-42. Dissolved barium (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

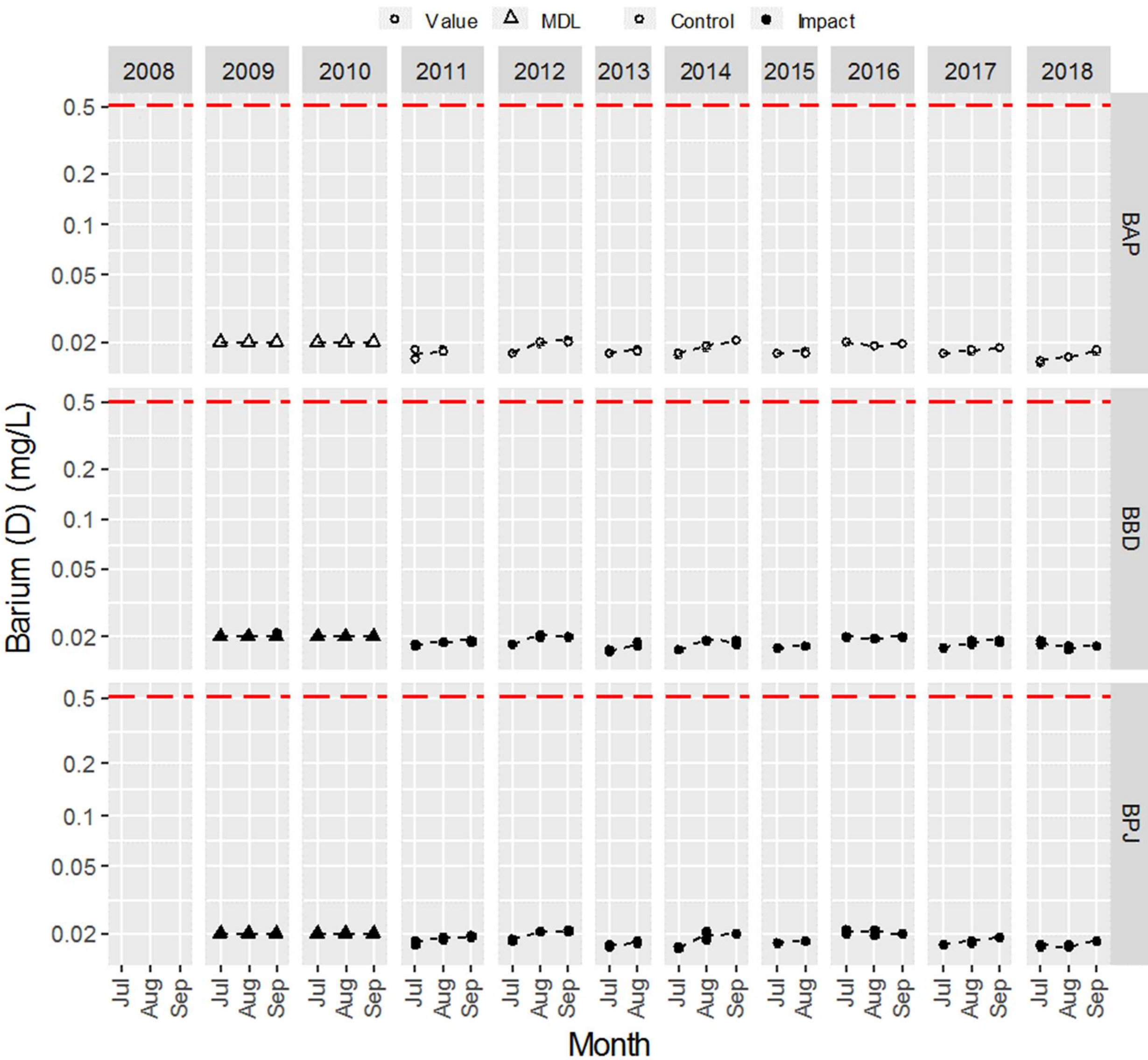


Figure 6-43. Dissolved boron (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

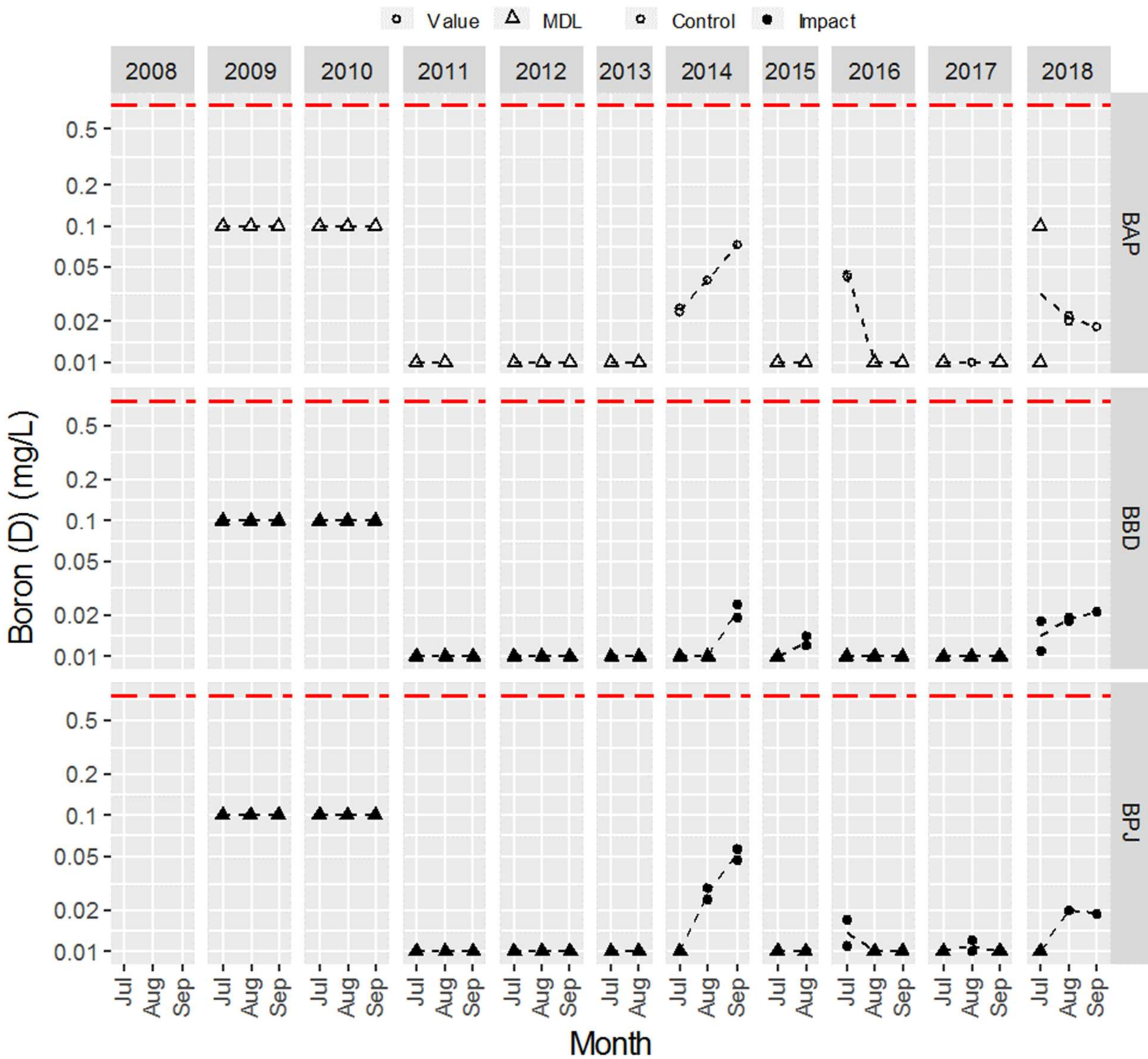


Figure 6-44. Dissolved copper (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

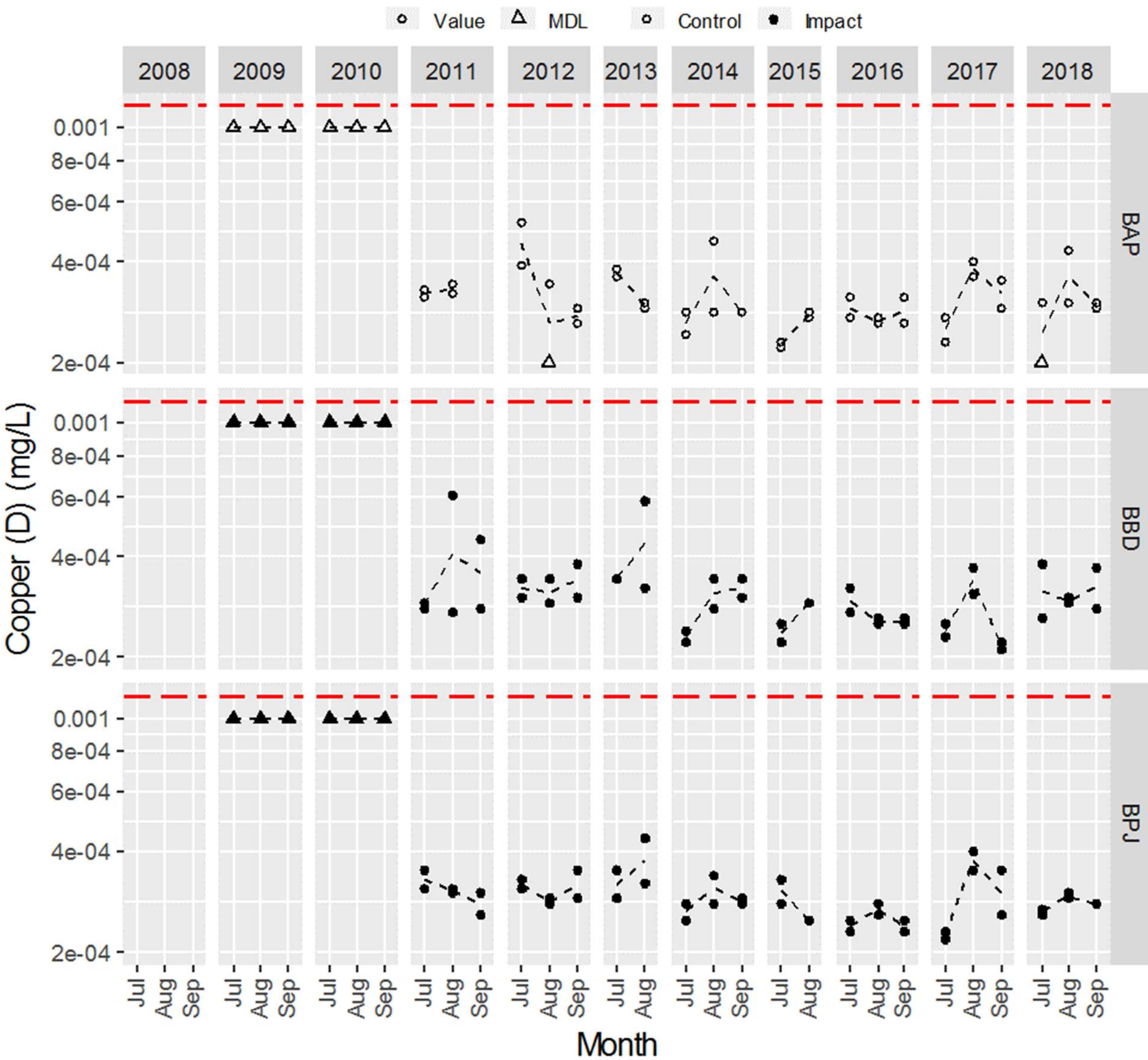


Figure 6-45. Dissolved iron (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

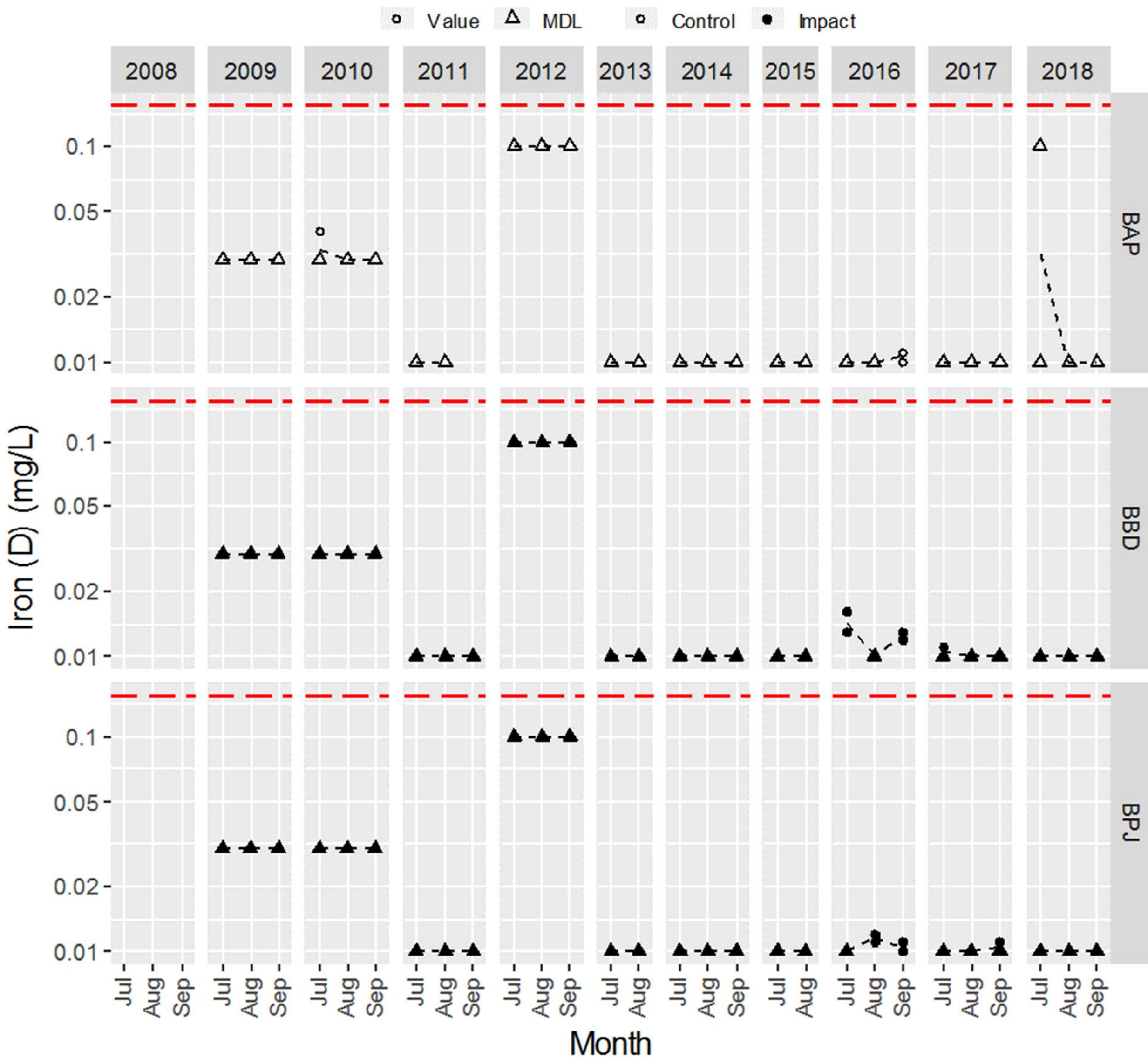


Figure 6-46. Dissolved lithium (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

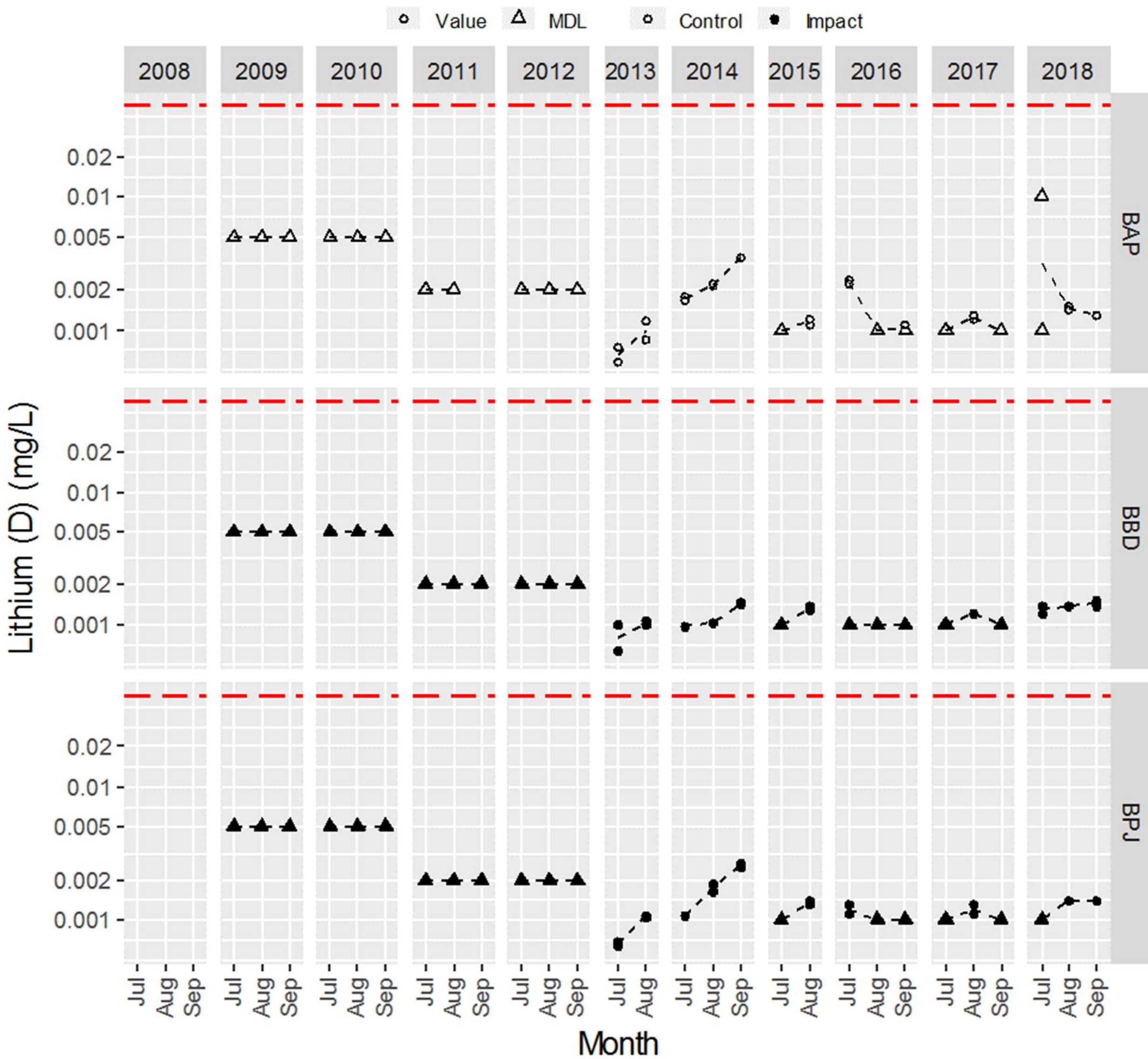


Figure 6-47. Dissolved manganese (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

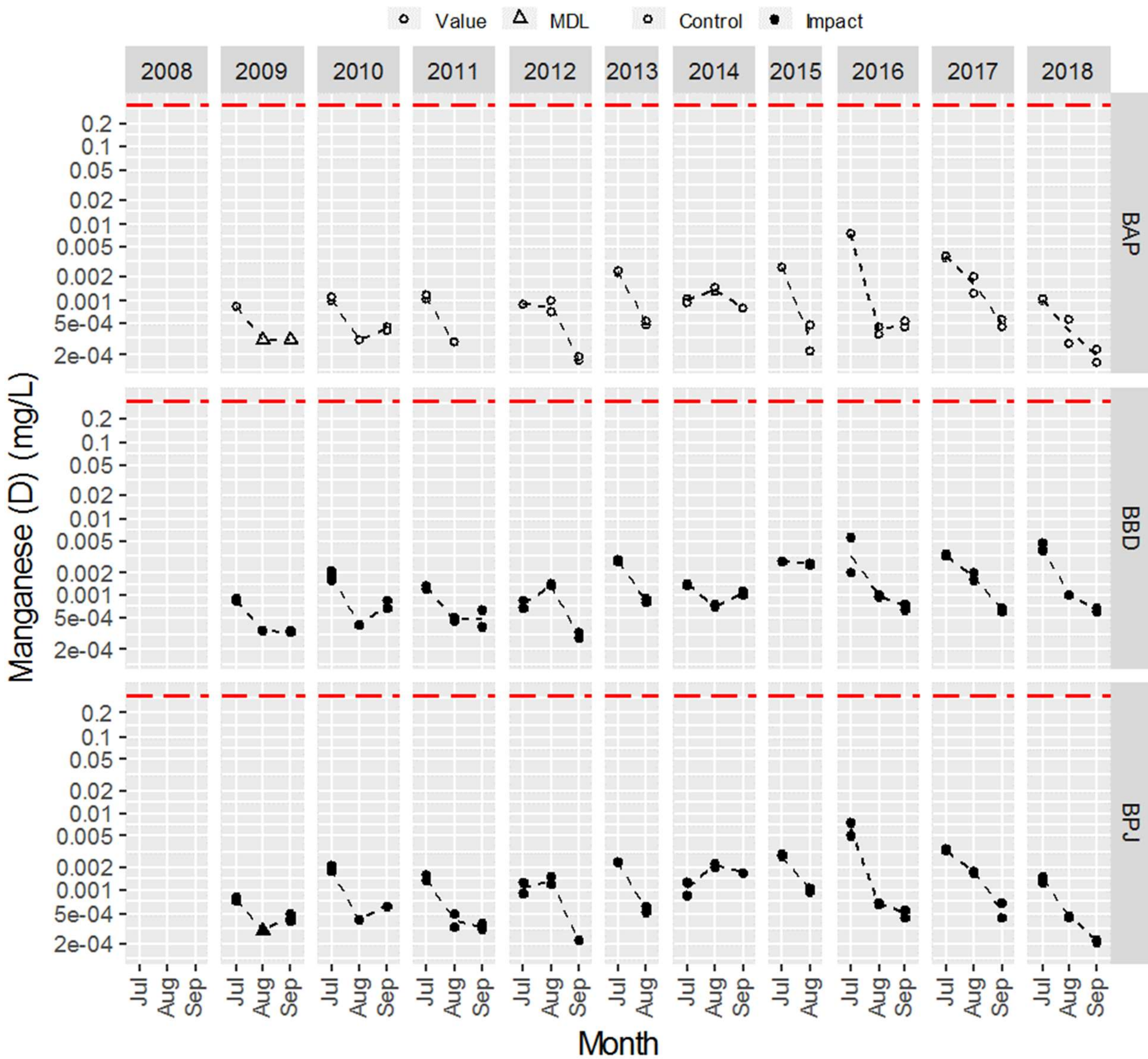


Figure 6-48. Dissolved molybdenum (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

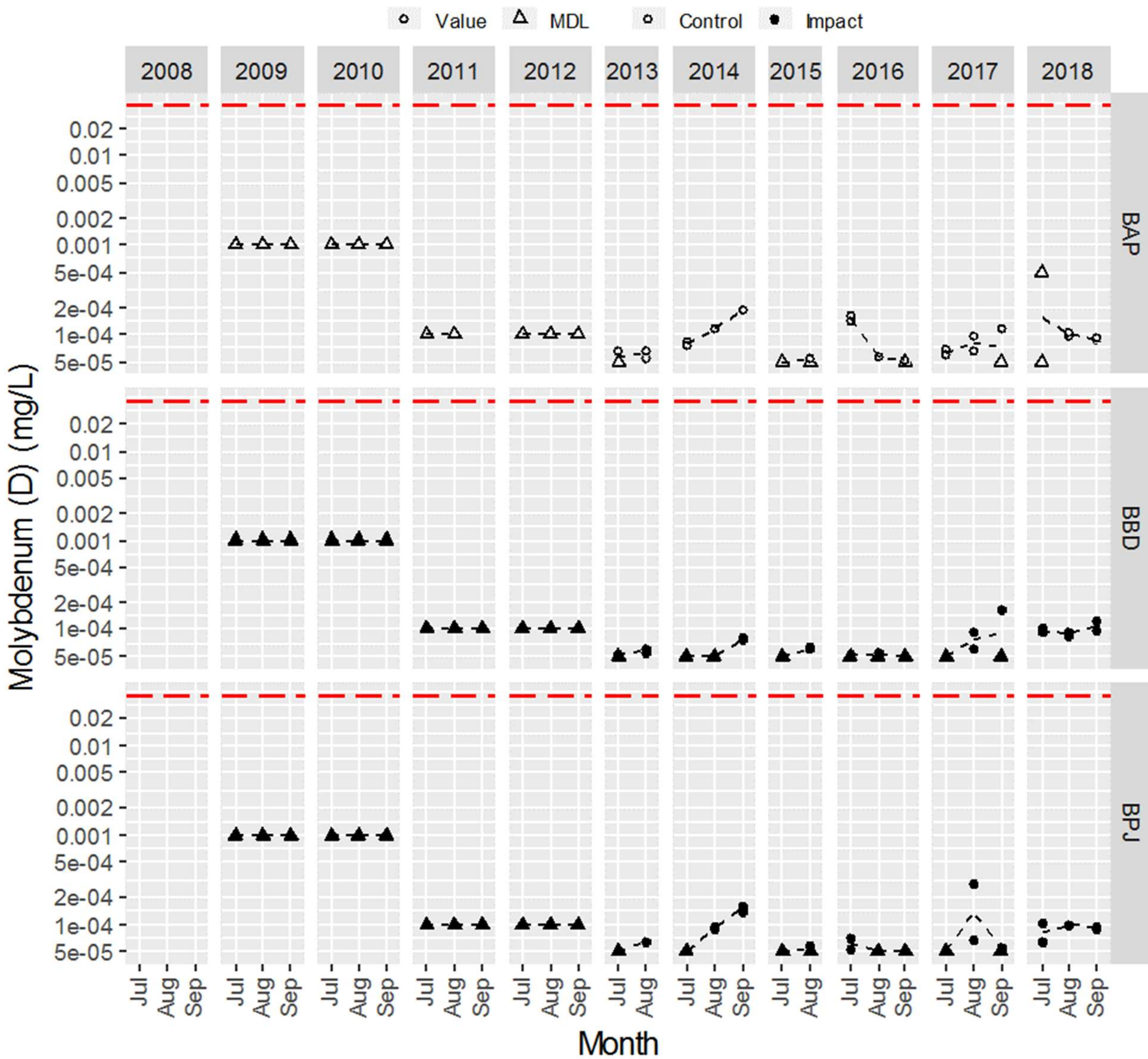


Figure 6-49. Dissolved strontium (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

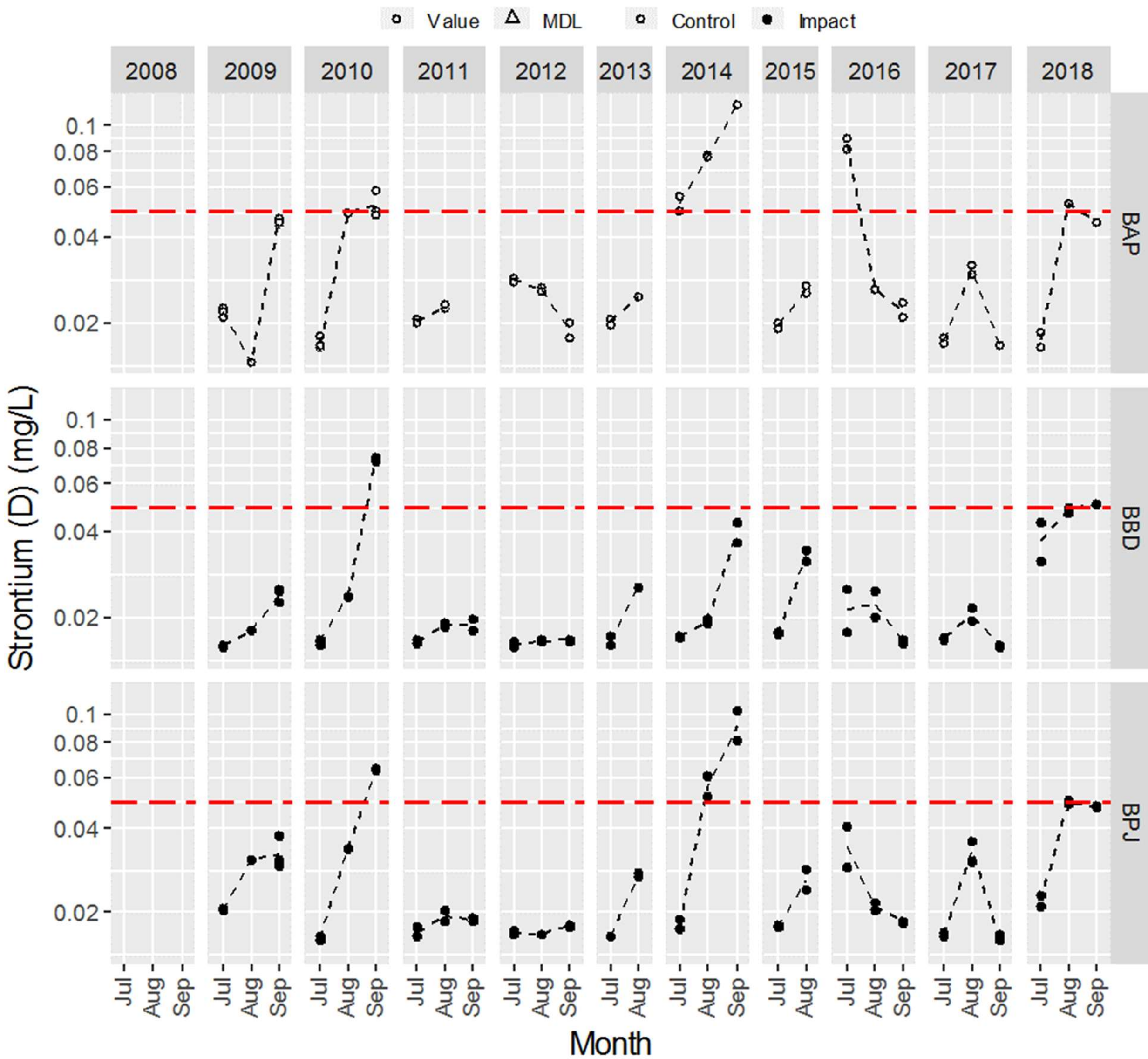


Figure 6-50. Dissolved uranium (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.

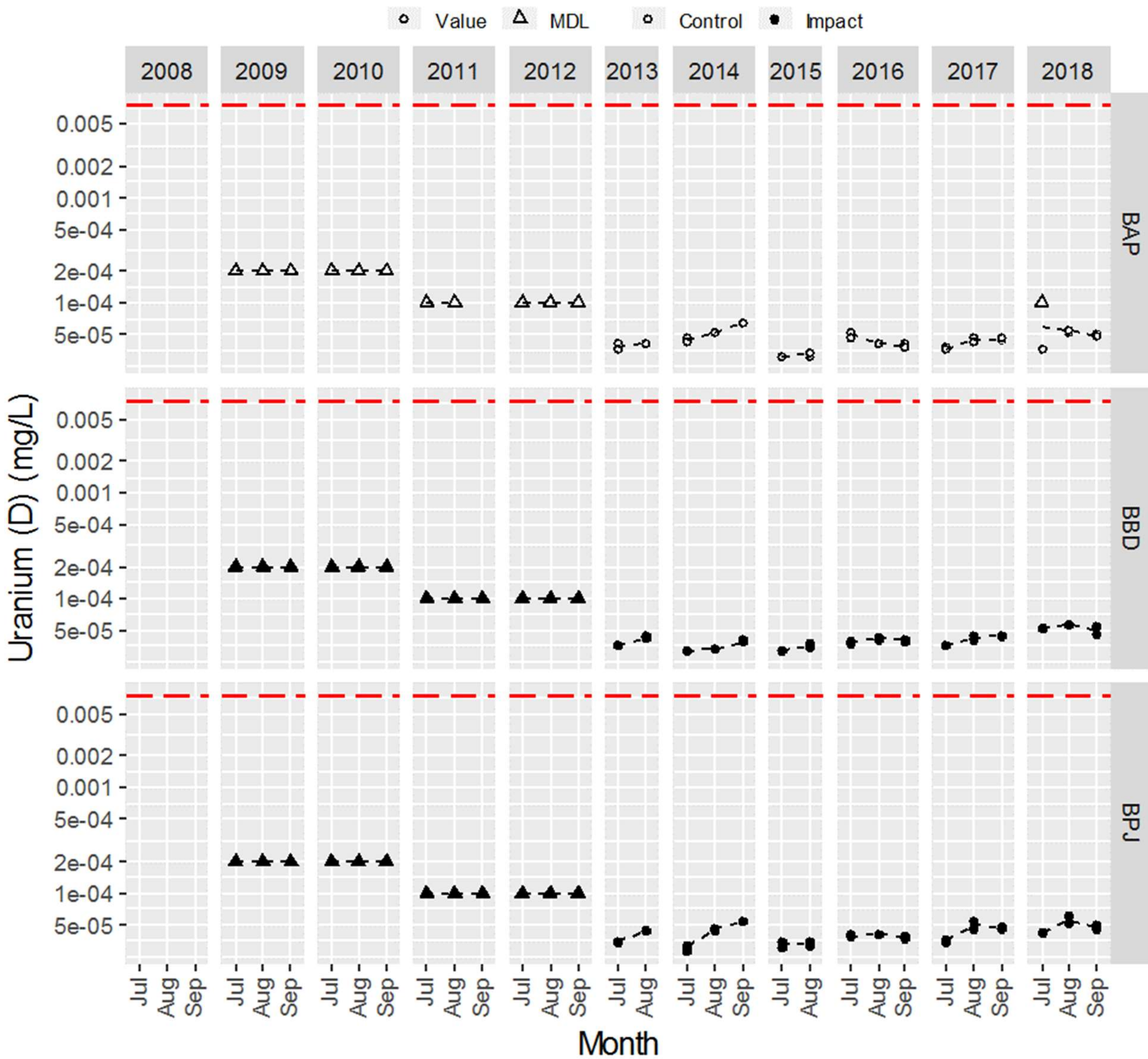
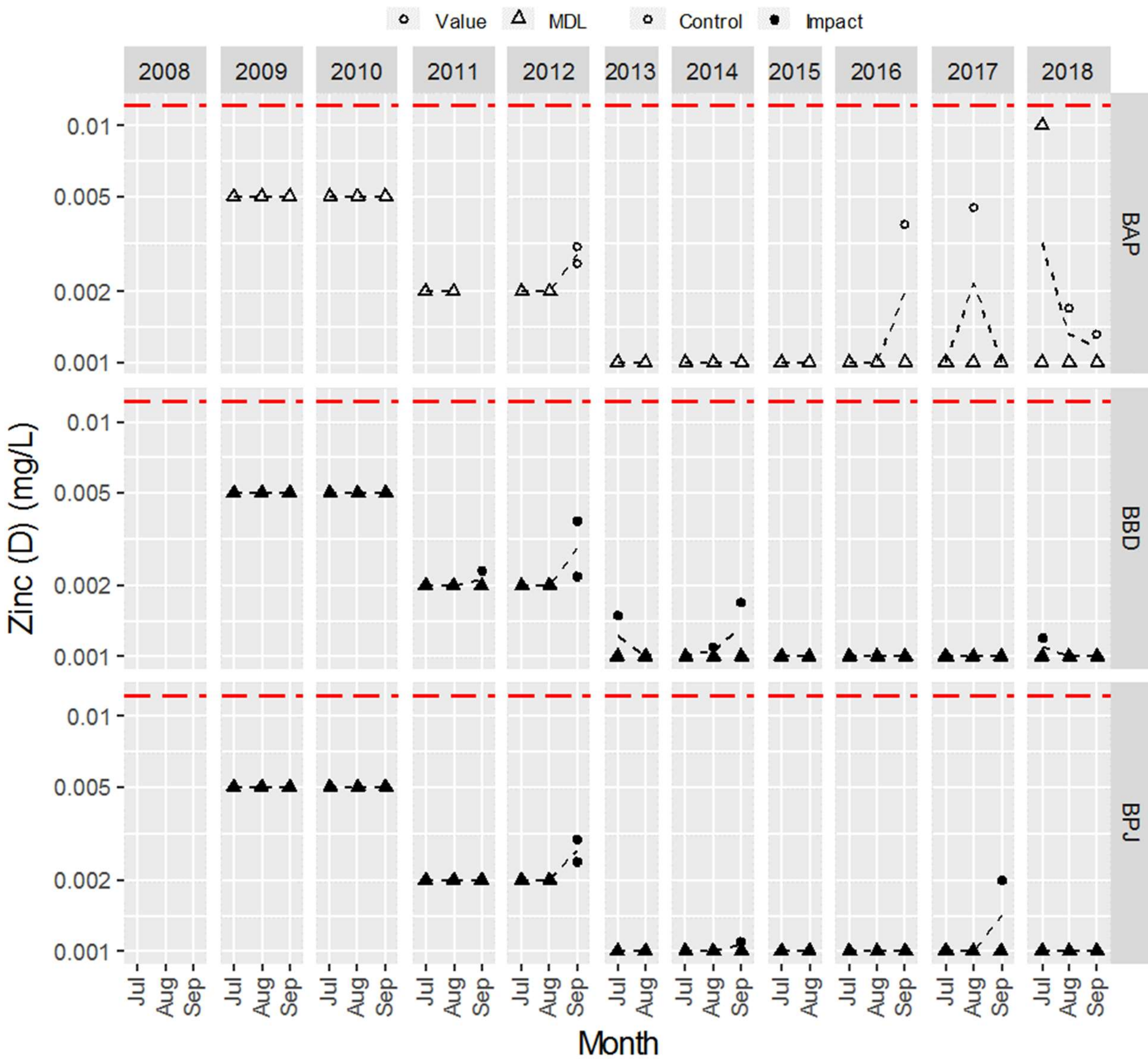


Figure 6-51. Dissolved zinc (mg/L) in water samples from Baker Lake since 2008.

Note: The red dashed line is the trigger value specific to Baker Lake.



Phytoplankton Tables and Figures

Table 6-2. Results of the BACI tests for phytoplankton variables at Baker Lake areas.

Parameter Measured	Test Area	n(B)	n(A)	Estimate	SE	P-value*	Effect size (%)		
							ES	LCI	UCI
Total biomass	BBD	27	3	-0.44	0.22	**0.05**	-35	-59	1
	BPJ	27	3	-0.31	0.17	**0.07**	-27	-48	3
Species	BBD	27	3	-0.07	0.05	0.16	-7	-16	3
	BPJ	27	3	-0.06	0.05	0.25	-6	-15	4

Notes:

* **Bolded** values are P-values < 0.1

Shaded cells indicate positive (increases) or negative (reduced) effect sizes of 20% or more

Test area = area compared to control (BAP)

n(B) = number of months in the "before" period

n(A) = number of months in the "after" period (i.e., in 2018)

Estimate = BACI model estimate of the 2018 change in mean for log-transformed data

SE = standard error of the estimate

P-value = two-tailed test of the null hypothesis of no change

ES = estimated effect size (i.e., 100%*(exp[Estimate]-1))

LCI = lower 95% confidence interval; UCI = upper 95% confidence interval