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2015 FARO MINE COMPLEX ADAPTIVE MANAGEMENT PLAN ANNUAL REVIEW

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1.0 INTRODUCTION

The original Faro Mine Complex Adaptive Management Plan (AMP) was developed and implemented in 2004 (GLL, 2004) to fulfil the requirements of the former site water licence. The AMP Implementation Protocol was intended to provide short-term management strategies for waters and facilities at the Faro Mine Complex that were recognized as representing potential environmental risks, but at that time not requiring immediate intervention. From 2004 until 2011, regular monthly reviews of the AMP were carried out along with a detailed annual review of the AMP. As part of the annual reviews, recommendations were made, and subsequently incorporated, into the AMP Implementation Protocol. These modifications included the addition of seasonal triggers for some events, discontinuation of monitoring of some indicator parameters, and removal of some groundwater sampling locations. Each of the modifications to the AMP was outlined in detail in AMP annual reviews prepared for Deloitte and Touche Inc. (2004 to 2008) and Denison Environmental Services (2009 to 2011), and in the 2014 Faro Mine Complex – AMP Update and Summary (SLR 2014). All of these modifications were incorporated into the Faro Mine Complex AMP (SLR 2014); and this was further modified in the Faro 2015 AMP Protocol Update (SLR 2015).

The current AMP is specifically designed to identify the indicators and triggers for action, the measures of statistically significant changes to be tracked, the monitoring locations and parameters, the sampling frequencies, the methods to be used to analyze and evaluate the data, and the actions to be taken for five potential events:

- Event 1 – Degraded Groundwater Quality in Rose Creek Aquifer
- Event 2 – Degraded Water Quality in Vangorda Creek Downstream of Mine Facilities
- Event 3 – Degraded Water Quality in Rose Creek Downstream of the Mine Facilities
- Event 4 – Degraded Seepage Quality from the Grum Rock Dump
- Event 5 – Degraded Water Quality in the North Fork of Rose Creek

The AMP Implementation Protocol requires that monthly and annual review of the AMP be undertaken. The annual review provides a mechanism to provide a status of identified events and to facilitate action to follow up on any triggers activated through the AMP process. In following sections, each AMP event is reviewed individually, including a brief summary of event history, and a discussion of trends and triggers observed and actions taken for each event in 2015. Any recommendations stemming from the ongoing monthly reviews, and associated trigger assessments, are also highlighted.

2.0 AMP EVENT 1 - DEGRADED GROUNDWATER QUALITY IN ROSE CREEK AQUIFER

2.1 General Description

Groundwater in the Rose Creek Valley Aquifer collects seepage and contaminants released from the tailings impoundments and has the potential to become contaminated to the degree where discharge from the aquifer to Rose Creek may result in a sustained adverse effect in Rose Creek. The environmental consequences of degraded water quality in the Rose Creek Valley Aquifer are the potential exposure of aquatic resources, terrestrial resources and human users of these resources to increased levels of contaminants in Rose Creek, Anvil Creek and the Pelly River.

2.2 Summary of AMP Event 1 Implementation Protocol

2.2.1 Evolution of AMP Event 1

Since degradation of groundwater quality is anticipated to occur progressively from the source area (tailings deposit) in a downgradient direction (Cross Valley Dam (CVD) and downstream), the trigger locations for the implementation of the AMP were selected to provide for the early detection of emerging trends or “plumes”. The trigger locations include locations downgradient of the tailings deposit as well as locations directly underlying the tailings deposit in the aquifer. The trigger locations for AMP Event 1 outlined in the original AMP Protocol were as follows:

- Groundwater quality downgradient of the Cross Valley Dam (location P03-09);
- Groundwater quality at the Intermediate Dam, below the downstream extent of the tailings deposit (locations X24 and X25);
- Groundwater quality (*i.e.*, the aquifer underlying the tailings deposit) approximately mid-length of the Intermediate Impoundment (location P03-08); and,
- Groundwater quality at the Second Impoundment Dam, approximately mid-length of the tailings facility (location P03-04).

Since the implementation of the AMP in 2004, AMP Event 1 has undergone extensive modification based on annual reviews and further investigations in the tailings area and Rose Creek Aquifer and groundwater wells.

In 2005, activation of the sulphate and zinc triggers at X14 and X15 in 2004 initiated a detailed data analysis that indicated that the increased concentrations were potentially a result of contaminant loading to the aquifer from drainage from the Emergency Tailings Area (ETA) and Faro waste rock dumps in the Old Faro Creek Channel. To support this assessment, predictive modelling was also performed to investigate the potential for contaminant loading to the downstream receiving environment and associated impacts. This model (developed by C. Wels) evaluated four scenarios:

- Base Case – using fall 2004 concentrations at X24 and X25, the model forecasted dissolved zinc concentrations in Rose Creek of 0.03 mg/L, which were not predicted to have a detrimental effect on water quality in the creek in the near future.
- Sensitivity Runs 1, 2 and 3 – modelled 20%, 50% and 100% increases in sulphate and dissolved zinc concentrations at X24 and X25. At that time the model predicted maximum dissolved zinc concentrations in Rose Creek of 0.041 mg/L, which at that time were within the range of concentrations seen in Rose Creek at X14 at that time.

Based on these results, it was determined that no further actions to the trigger activation was required, other than ongoing monitoring and assessment of related groundwater and surface water quality.

In 2006, dissolved iron (originally in AMP Event 1) was removed as an indicator parameter as investigations into trigger activation for iron indicated that the elevated levels were primarily due to variations and inconsistency in sampling methods during the reference period (1998-2002), rather than actual changes in water quality.

In 2008, due to issues related to sediment accumulation in the wells, Event 1 monitoring locations X24-94A, B and C were decommissioned and removed from the AMP monitoring program. X24-96D remained as part of the AMP monitoring program for Event 1.

As part of the 2011 AMP annual review, it was highlighted that the sulphate and dissolved zinc concentrations at the AMP trigger locations were starting to exceed the limits of the model

developed in 2004. Therefore it was recommended that the model developed by C. Wels in 2004 in support of AMP Event 1 be reviewed and updated, if required, to provide a tool for the ongoing assessment of trigger activation for AMP Event 1.

In response, on behalf of YG-AAM, C. Wels (RGC 2015) carried out a review of the AMP Event 1 monitoring program, including assessment of the trigger locations. The following are the key findings of that assessment as they relate to AMP Event 1:

- Wells X24D, X25A and X25B have little value for future AMP monitoring as the sulphate and zinc plumes have moved beyond their location in the Intermediate Dam and should be removed as trigger locations;
- Well P03-09 (ports 6 and 9) should be retained as AMP trigger locations;
- Wells P05-01 (ports 2 and 4), P05-02, and P01-11 be added as trigger locations; and,
- A single trigger concentration of 0.2 mg/L zinc be used as an interim threshold, instead of a trend-based approach, that, if exceeded, would initiate installation of a seepage interception system (SIS) near the Cross Valley Dam.

The previous triggers were 3 consecutive results above the threshold values, in correspondence with a quarterly monitoring schedule. For the implementation of the proposed interim threshold of 0.2 mg/L zinc, it was recommended by C. Wels that the trigger for action be revised to 2 sampling results to correspond with the revised bi-annual sampling frequency.

If the dissolved zinc concentration in any of the trigger locations is greater than the threshold value for two consecutive results, the well should be re-sampled to confirm the exceedance. If confirmed, a response plan should be developed to initiate the design and installation of a SIS.

2.2.2 Current Implementation Protocol

Zinc is currently the primary contaminant of concern at the primary AMP assessment locations (P03-09, P05-01, P05-02 and P01-11). Ports 3 and 5 of P05-01 were not included in the 2015 Updated AMP Protocol; but are however, recommended for inclusion to the AMP by RGC (as described above). Therefore, they were assessed under Event 1 in 2015.

To assess potential changes in concentrations at the primary locations, trend assessments of secondary AMP indicator parameters (sulphate, manganese, magnesium, alkalinity and calcium) are also included in the assessment of AMP Event 1. The purpose of secondary AMP locations is to support the interpretation of water quality conditions where primary AMP indicators demonstrate declining water quality, and therefore no thresholds are designated for secondary AMP locations.

A summary of the 2015 AMP assessment criteria for Event 1 is provided in Table 1.

Table 1: Event 1 AMP Assessment Criteria

Indicators	Locations	Thresholds	Frequency
Zn-D	P03-09 (ports 6 and 9)	2 consecutive results > 0.2 mg/L	Bi-Annual (Spring and Fall)
Zn-D	P05-01 (ports 2, 3, 4 and 5)	2 consecutive results > 0.2 mg/L	Bi-Annual (Spring and Fall)
Zn-D	P05-02	2 consecutive results > 0.2 mg/L	Bi-Annual (Spring and Fall)
Zn-D	P01-11	2 consecutive results > 0.2 mg/L	Bi-Annual (Spring and Fall)
Sulphate Mn-T Mg-T Alkalinity Ca-T	P03-09 (ports 6 and 9)	None	Bi-Annual (Spring and Fall)
Sulphate Mn-T Mg-T Alkalinity Ca-T	P05-01 (ports 2, 3, 4 and 5)	None	Bi-Annual (Spring and Fall)
Sulphate Mn-T Mg-T Alkalinity Ca-T	P05-02	None	Bi-Annual (Spring and Fall)
Sulphate Mn-T Mg-T Alkalinity Ca-T	P01-11	None	Bi-Annual (Spring and Fall)

2.3 Data Review

Assessment under the AMP of the relevant groundwater quality data from P03-09, P05-01, P05-02 and P01-11 was carried out using groundwater quality data collected in June and September of 2015 (summarized below in Table 2).

Please note that at the time of this report, not all of the sampling locations described in Table 2 were sampled in 2015 and much of the historical data (2012 – 2014) was not available. Additionally, an AMP assessment requires the review of two consecutive results. A more extensive assessment of Event 1 will occur in the 2016 AMP Annual Review.

Table 2: Summary of AMP Event 1 Assessment

Indicators	Locations	Trigger Activation	Result
Zn-D	P03-09 (ports 6 and 9)	No trigger activated	<ul style="list-style-type: none"> Port 6: No 2015 data. 2012 and 2014 historical data (0.005 and 0.002 mg/L, respectively) did not exceed the threshold. Port 9: No June data. September 2015 dissolved zinc concentration (0.060 mg/L) did not exceed the threshold. 2012 and 2014 historical data (0.008 and 0.003 mg/L, respectively) did not exceed the threshold.
Zn-D	P05-01 (ports 2, 3, 4 and 5)	No trigger activated	<ul style="list-style-type: none"> Ports 2 and 4: No June data. September 2015 dissolved zinc concentration at ports 2 and 4 were the same (0.01 mg/L) and were below the threshold. Port 3: June and September 2015 dissolved zinc concentration (0.005 and 0.008 mg/L, respectively) did not exceed the threshold value. No historical data. Port 5: June and September 2015 dissolved zinc concentration (0.006 and 0.006 mg/L, respectively) did not exceed the threshold value. No historical data.
Zn-D	P05-02	No trigger activated	No June data. September 2015 dissolved zinc concentration (0.07 mg/L) did not exceed the threshold. No historical data.
Zn-D	P01-11	No trigger activated Note that a spring 2016 result greater than 0.2 mg/L will activate this trigger	June 2015 dissolved zinc concentration (0.008 mg/L) did not exceed the threshold value; however, the September 2015 concentration (0.234 mg/L) did exceed the threshold value of 0.2 mg/L, but was not part of two consecutive exceedances. A duplicate sample collected at this well, and RPD values indicate that this is a reliable result. 2012 and 2014 historical data (0.005 and 0.007 mg/L, respectively) did not exceed the threshold.
Sulphate Mn-D Mg-D Alkalinity Ca-D	P05-01 (port 2)	Not Applicable	<ul style="list-style-type: none"> statistically significant increase in sulphate concentrations only September 2015 data; insufficient data to complete Mn-D trend assessment only September 2015 data; insufficient data to complete Mg-D trend assessment increase in alkalinity concentrations; but not statistically significant only September 2015 data; insufficient data to complete Ca-D trend assessment

Indicators	Locations	Trigger Activation	Result
Sulphate Mn-D Mg-D Alkalinity Ca-D	P05-01 (port 3)	Not Applicable	<ul style="list-style-type: none"> statistically significant increase in sulphate concentrations statistically significant increase in Mn-D concentrations statistically significant increase in Mg-D concentrations statistically significant increase in alkalinity statistically significant increase in Ca-D concentrations
Sulphate Mn-D Mg-D Alkalinity Ca-D	P05-01 (port 4)	Not Applicable	<ul style="list-style-type: none"> statistically significant increase in sulphate concentrations only September 2015 data; insufficient data to complete Mn-D trend assessment only September 2015 data; insufficient data to complete Mg-D trend assessment statistically significant increase in alkalinity only September 2015 data; insufficient data to complete Ca-D trend assessment
Sulphate Mn-D Mg-D Alkalinity Ca-D	P05-01 (port 5)	Not Applicable	<ul style="list-style-type: none"> statistically significant increase in sulphate concentrations statistically significant increase in Mn-D concentrations statistically significant increase in Mg-D concentrations statistically significant increase in alkalinity statistically significant increase in Ca-D concentrations
Sulphate Mn-D Mg-D Alkalinity Ca-D	P05-02	Not Applicable	<ul style="list-style-type: none"> statistically significant increase in sulphate concentrations only September 2015 data; insufficient data to complete Mn-D trend assessment only September 2015 data; insufficient data to complete Mg-D trend assessment increase in alkalinity but not statistically significant only September 2015 data; insufficient data to complete Ca-D trend assessment
Sulphate Mn-D Mg-D Alkalinity Ca-D	P01-11	Not Applicable	<ul style="list-style-type: none"> statistically significant increase in sulphate concentrations statistically significant increase in Mn-D concentrations increase in Mg-D concentrations but not statistically significant statistically significant increase in alkalinity increase in calcium concentrations but not statistically significant

2.4 Recommendations

Based on the 2015 data review, the following recommendations have been made to support the ongoing assessment of AMP Event 1:

- As previously noted, as per the RGC 2015 report, Ports 3 and 5 of P05-01 were recommended for inclusion to the AMP. These ports were successfully sampled in 2015 and should continue to be included as part of the 2016 AMP monitoring and assessment program, and be included in the next AMP Protocol update.
- The current AMP triggers at the groundwater wells of Event 1 are interim, as per RGC (2015). The permanent AMP trigger thresholds at these locations should be established on the basis of an updated water and load balance and a new solute transport model for Rose Creek valley (see RGC 2015 for details). The permanent AMP triggers should then be included in the next AMP Protocol update.
- Due to the exponential increase in total zinc concentrations measured at P0-11 during the September 2015 sampling event, it is recommend that June 2016 total zinc results be reviewed (including a trend assessment and groundwater quality review) immediately upon receipt of laboratory results, in order to determine if the trigger has been activated.

3.0 AMP EVENT 2 - DEGRADED WATER QUALITY IN VANGORDA CREEK DOWNSTREAM OF MINE FACILITIES

3.1 General Description

The water quality in Vangorda Creek downstream of the Vangorda Plateau mine facilities could be negatively affected by surface water runoff from the mine facilities and groundwater seepage. The water quality in Vangorda Creek downstream of the mine facilities is monitored on a monthly basis at AMP trigger location V8 at the footbridge in the Town of Faro. Water quality is also measured upstream of V8 in Vangorda Creek at location V5 in the West Fork, as well as in the main stem at VGMAIN as part of the Pelly Aquatics surface water quality program.

The environmental consequences of degraded water quality in Vangorda Creek is the potential exposure of aquatic resources, terrestrial resources and human users of these resources to increased levels of contaminants in Vangorda Creek, and possibly the Pelly River.

3.2 Summary of AMP Event 2 Implementation Protocol

3.2.1 Evolution of AMP Event 2

Since implementation of the AMP in 2004, AMP Event 2 has undergone slight modifications based on annual review and further investigations into water quality in this area. Specifically in 2006 as part of the 2005 annual review, an assessment was carried out that identified statistically significant seasonal differences in sulphate concentrations at V8 during the AMP reference period (1998 to 2002). In response the AMP, threshold values for sulphate were modified to account for lower levels during the open water season (May to October) and higher levels during the winter low flow period (November to April). Additionally, total copper was originally part of the AMP protocol for V8 and all other surface water AMP Events. Review of previous AMP Annual Reviews and water quality data at each location indicates that, for the most part, concentrations of total copper are typically at or below detection limits. As such, total copper has been removed as an indicator parameter for the Vangorda Creek at V8 and all other surface water quality AMP Events.

3.2.2 Current Implementation Protocol

Zinc is currently the primary contaminant of concern, and zinc and sulphate are the primary indicators of acid rock drainage. Review of total zinc, sulphate and total suspended solids (TSS) are included in the AMP Event 2 assessment at V8.

A summary of the 2015 AMP assessment criteria for Event 2 is provided in Table 3.

Table 3: Event 2 AMP Assessment Criteria

Indicators	Locations	Thresholds	Frequency
Zn-T and TSS	V8	<ul style="list-style-type: none"> • 3 consecutive results > 75th percentile of reference period (Zn-T = 0.05 mg/L; TSS = 8 mg/L); or • Statistically significant trend projects > 75th percentile of the reference period within 3 years. 	Monthly
Sulphate	V8	<ul style="list-style-type: none"> • 3 consecutive results > 75th percentile of the open water reference period (75 mg/L); or • Statistically significant trend projects > 75th percentile of the open water reference period within 3 years. 	Monthly (May - October)
Sulphate	V8	<ul style="list-style-type: none"> • 3 consecutive results > 75th percentile of the winter reference period (171 mg/L); or • Statistically significant trend projects > 75th percentile of the winter reference period within 3 years. 	Monthly (November - April)

3.3 Data Review

Assessment under the AMP of the relevant water quality data from V8 was carried out using 2015 water quality data. A summary of the water quality data for V8 from 2003 to 2015 is provided in Figures 1 to 3. The results of the Event 2 assessment are summarized in Table 4.

In 2015, the sulphate threshold at V8 was exceeded in both the open water and winter season: in March during the winter period and from July to October during the open water period. The discharge of treated, sulphate-rich, water from the Vangorda Treatment Plant during the open water seasons (May to October) can be attributed to the observed elevated sulphate concentrations during July and August. During the winter low flow period, the elevated sulphate concentrations are most likely due to seepage and groundwater inflows from the Vangorda Plateau Mine site. During both the winter and open water season, increasing trends in sulphate were observed, but they are not statistically significant at this time.

During this same period, the TSS threshold was exceeded in May, August, September and October. The highest concentration (measured in May; 56.6 mg/L) is associated with elevated flows during spring freshet. Other exceeding concentrations are typical of the natural drainages in the area and were within concentrations historically measured at V8. Currently, there is an increasing trend in TSS, but it is not statistically significant at this time.

Total zinc concentrations exhibit a non-significant decreasing trend with one threshold exceedance measured in 2015 (October; 0.06 mg/L).

Table 4: Summary of AMP Event 2 Assessment

Indicators	Trigger Activation	Results
Zn-T	No	<ul style="list-style-type: none"> 75th percentile threshold of 0.05 mg/L was not exceeded during three consecutive events in 2015. Decreasing trend in total zinc but statistically significant.
TSS	Yes	<ul style="list-style-type: none"> 75th percentile threshold of 8 mg/L was exceeded during three consecutive events in 2015 (August, September and October 2015). Increasing trend in TSS but not statistically significant.
Sulphate (May – October)	Yes	<ul style="list-style-type: none"> 75th percentile threshold of 75 mg/L was exceeded during three consecutive events in 2015 (July, August, September and October 2015). Increasing trend in sulphate but not statistically significant.
Sulphate (November – April)	No	<ul style="list-style-type: none"> 75th percentile threshold of 171 mg/L was not exceeded during three consecutive events in 2015. Increasing trend in sulphate but not statistically significant.

3.4 Recommendations

Based on the 2015 data review for AMP Event 2, the following recommendations have been made to support the ongoing assessment of AMP Event 2:

- With trigger exceedances of sulphate and TSS at V8, it is recommended that data from V5 and VGMAIN be reviewed to supplement the V8 data review.

4.0 AMP EVENT 3 - DEGRADED WATER QUALITY IN ROSE CREEK DOWNSTREAM OF MINE FACILITIES

4.1 General Description

The water quality in Rose Creek downstream of the mine facilities could be negatively affected by surface water runoff from the mine facilities, groundwater seepage from the waste rock and Rose Creek Tailings Facility, site discharges at X13 and effluent discharges from the Cross Valley Pond (CVP) and the Interim Water Treatment Plant (IWTP).

The environmental consequences of degraded water quality in Rose Creek is the potential exposure of aquatic resources, terrestrial resources and human users of these resources to increased levels of contaminants in Rose Creek, Anvil Creek and the Pelly River.

4.2 Summary of AMP Event 3 Implementation Protocol

4.2.1 Evolution of AMP Event 3

Since implementation of the AMP in 2004, AMP Event 3 has undergone slight modifications based on annual review and further investigations into water quality in this area. The original AMP was modified to take into consideration the variations in sample frequency at X14 from monthly to weekly during periods of discharge. This was done to ensure consistency with the reference period sample frequency and the basis for determining the thresholds. For the

assessment of triggers during periods of weekly sampling during periods of discharge, the weekly concentrations are averaged for the month. This average monthly value is then carried forward and assessed as per the AMP Protocol.

To support the AMP assessment at X14, monthly trend assessments of sulphate and total zinc levels at X13 and X10 were incorporated into the monthly assessment of AMP Event 3 at the end of 2014. As noted in Section 3.2.1, total copper has been removed as an indicator parameter for this AMP Event. In addition, as recommended by CH2M Hill (2015) to ensure early indication of changes to water quality stemming from seepage and groundwater inflows, the list of indicator parameters at X14 were expanded to include additional key indicator parameters. Specifically:

- Magnesium and manganese be added to the primary indicator parameter list at X14; and,
- Alkalinity and calcium be considered as secondary indicator parameters at X14, to support the findings of the primary indicator parameters.

Monitoring magnesium trends will help provide early warning indication of acid mine drainage potential due to magnesium's tendency to follow increases in sulphate concentrations. Monitoring manganese trends will help to clarify the relationship between zinc and manganese releases, which has been erratic to date.

Alkalinity and calcium are considered secondary indicator parameters because a declining trend will indicate depletion of the neutralization potential of carbonate minerals in the rock dumps.

4.2.2 Current Implementation Protocol

Zinc is currently the primary contaminant of concern and zinc and sulphate are the primary indicators of acid rock drainage. Review of total zinc and sulphate are included in the AMP assessment at X14. Water quality is measured monthly at station X14, and weekly during periods of effluent discharge (at X5 and Effluent Pipeline Outflow). The primary AMP assessment location at X14 includes a review of total zinc, sulphate, alkalinity, total manganese, total magnesium and total calcium. To assess potential changes in concentrations at X14 and delineate sources, monthly trend assessments of indicator parameters at secondary AMP locations (X13 and X10) are also included in the monthly assessments of AMP Event 3. The purpose of secondary AMP locations is to support the interpretation of water quality conditions where primary AMP locations demonstrate declining water quality, and therefore no thresholds are designated for secondary AMP locations. Water quality is also measured upstream in Rose Creek at X10 and X3A, as well as at several stations located in the North Fork Rose Creek (NFRC). Generally, total metals data are required for AMP analysis, however because X13 is classified as a seepage location, only dissolved metals data is collected and available for the assessment.

A summary of the AMP assessment criteria for Event 3 is provided in Table 5.

Table 5: Event 3 AMP Assessment Criteria

Indicators	Locations	Thresholds	Frequency
Zn-T and Sulphate	X14	<ul style="list-style-type: none"> 3 consecutive results > 75th percentile of reference period (Zn-T = 0.08 mg/L; Sulphate = 166 mg/L); or Statistically significant trend projects > 75th percentile of reference period within 3 years. 	Weekly during discharge; otherwise monthly
Alkalinity	X14	<ul style="list-style-type: none"> Statistically significant decreasing trend <ul style="list-style-type: none"> Carried out seasonally - Open Water (May to October) and Winter (November to April) 	Weekly during discharge; otherwise monthly
Mn-T Mg-T Ca-T	X14	<ul style="list-style-type: none"> Statistically significant increasing trend 	Weekly during discharge; otherwise monthly
Zn-T Sulphate Mn-T Mg-T Alkalinity Ca-T	X10	None	Weekly during discharge; otherwise monthly
Zn-D Sulphate Mn-D Mg-D Alkalinity Ca-D	X13	None	Weekly during discharge; otherwise monthly

4.3 Data Review

Assessment under the AMP of the relevant water quality data from X14, X10 and X13 was carried out using the 2015 water quality data. The water quality data from X14 for 2003 to 2015 is presented in Figures 4 to 9. The results of the Event 3 assessment are summarized in Table 6.

Currently, the trigger for sulphate continues to be exceeded during the year, primarily during low flow periods and during periods of discharge of sulphate-rich treated effluent. In 2015, the sulphate threshold was exceeded in three consecutive months during the winter low flow season (January to April) at X14. Monthly (but not consecutive) exceedances of the sulphate trigger were measured in August, October and November. Comparison of the 2015 sulphate concentrations to historical values indicates sulphate levels are at their highest in Rose Creek during the winter months. Currently, a statistically significant increasing trend continues to be observed for sulphate with levels above the 166 mg/L threshold value. It should be noted that this trend is not new and was identified previously in the 2011 (Denison Environmental Services) and 2014 (SLR) AMP Annual Reviews. In the past, elevated sulphate at X14 has typically been associated with the following:

- Inflow of high sulphate groundwater inflows (baseflow), which is more evident in the winter low flow period;

- Inflow of high sulphate seepage from the toe of the CVD (*i.e.*, X13) which is also more evident during the winter low flow periods; and,
- Discharge of compliant effluent from the CVP via X5 which contains elevated levels of sulphate.

In 2015, compliant discharge via X5 to Rose Creek occurred in all months except for July, September and December, with a relatively small volume discharged in April. The discharge of compliant effluent, particularly during the winter low flow period, is the primary source of some of the elevated sulphate concentrations measured at X14. During periods of no or minimal active discharge, the high sulphate concentrations observed were most likely due to groundwater and seepage contributions.

The average total zinc concentrations at X14 were well above the threshold value of 0.08 mg/L for all months except June and September. Additionally, there is a statistically significant increase in total zinc concentrations at this location, which will be greater than the 75th percentile of the reference period in less than three years. The source of these elevated concentrations of zinc at X14 is the increased loading in the North Fork Rock Drain (NFRD) area, as demonstrated by statistically significant increasing total zinc concentrations measured at X10 (upstream of X14 in Rose Creek).

Assessment of the winter season alkalinity indicates a decreasing trend that is not currently statistically significant. The open water season trend in alkalinity is increasing but is also not statistically significant at this time. Alkalinity during the open water season observed at X14 is likely due to the discharge of treated water via X5.

Trend assessment of manganese, magnesium and calcium were also performed for concentrations measured at X14 in 2015. Total magnesium, manganese and calcium all had had statistically significant increasing trends.

Trend assessments were carried out on Event 3 secondary locations (X10 which is upstream of X14 in Rose Creek and upstream of the seepage from the Cross Valley Dam at X13). The trend assessment results are presented in Table 5. A comparison of sulphate concentrations from X14, X10 and X13 is presented in Figure 10. A comparison of zinc concentrations from X14, X10 and X13 is presented in Figure 11.

The X10 trend analyses indicate that, although there is a significant increase in sulphate at X14, the increasing trend at X10 is not significant. However, there is a notable increase in winter sulphate concentrations in this region of Rose Creek. This increase in winter sulphate concentrations at X14 is consistent with the data in the North Fork Rose Creek in the area upstream of the NFRD and adjacent to the Zone II Outwash area and the Northeast waste rock dumps. There are also statistically significant increasing trends in total zinc and manganese concentrations at X10 which is dominated by the upstream input from the NFRD area, similar to at X14 (see Section 6.0 – Event 5).

The X13 (seepage from the Cross Valley Dam) trend analyses indicates that there are statistically significant increasing trends in all parameters measured (sulphate, dissolved zinc, dissolved manganese, dissolved magnesium, alkalinity and dissolved calcium) at this location. These increasing trends are indicative of the increasing loading from the tailings area to the downstream receiving environment.

Table 6: Summary of AMP Event 3 Assessment

Indicators	Location	Trigger Activation	Results
Zn-T	X14	Yes	<ul style="list-style-type: none"> 75th percentile threshold of 0.08 mg/L was exceeded during three consecutive months (July 2014 to May 2015 and October 2015 to December 2015). Statistically significant increasing trend in concentrations projected > 75th percentile of reference period within 3 years.
Sulphate	X14	Yes	<ul style="list-style-type: none"> 75th percentile threshold of 166 mg/L was exceeded during three consecutive months (January to April 2015). Statistically significant increasing trend in concentrations projected > 75th percentile of reference period within 3 years.
Alkalinity (May - October)	X14	No	<ul style="list-style-type: none"> Increasing trend in alkalinity but not statistically significant
Alkalinity (November - April)	X14	No	<ul style="list-style-type: none"> Decreasing trend in alkalinity but not statistically significant
Mn-T	X14	Yes	<ul style="list-style-type: none"> Statistically significant increasing trend in Mn-T concentrations
Mg-T	X14	Yes	<ul style="list-style-type: none"> Statistically significant increasing trend in Mg-T concentrations
Ca-T	X14	Yes	<ul style="list-style-type: none"> Statistically significant increasing trend in Ca-T concentrations
Zn-T Sulphate Mn-T Mg-T Alkalinity Ca-T	X10	Not Applicable	<ul style="list-style-type: none"> Statistically significant increasing trend in Zn-T concentrations Increasing trend in sulphate concentrations but not statistically significant. Statistically significant increasing trend in Mn-T concentrations Increasing trend in Mg-T concentrations but not statistically significant Increasing trend in alkalinity but not statistically significant Decreasing trend in Ca-T concentrations but not statistically significant

Indicators	Location	Trigger Activation	Results
Zn-D Sulphate Mn-D Mg-D Alkalinity Ca-D	X13	Not Applicable	<ul style="list-style-type: none"> Statistically significant increasing trend in Zn-D concentrations Statistically significant increasing trend in sulphate concentrations Statistically significant increasing trend in Mn-D concentrations Statistically significant increasing trend in Mg-D concentrations Statistically significant increasing trend in alkalinity Statistically significant increasing trend in Ca-D concentrations

4.4 Recommendations

Based on the 2015 data review for AMP Event 3, the following recommendations have been made to support the ongoing assessment of AMP triggers at X14:

- As recommended in the 2014 Faro Annual Report (SLR) and the follow up document by CH2M Hill (2015) it is recommended that the AMP Protocol at X14 be updated to provide for thresholds at X14 based on data with and without the discharge of compliant effluent from X5, in order to adequately assess changes in indicator parameters at X14 and delineate sources.

5.0 AMP EVENT 4 - DEGRADED SEEPAGE QUALITY FROM THE GRUM ROCK DUMP

5.1 General Description

Subsurface and surface seepage from the Grum Dump ultimately flows into Vangorda Creek and has the potential to become contaminated to such a degree that the receiving environment in Vangorda Creek is negatively affected. Seepage collects in a small sump (V15), where a collection sump and ditch collect and convey seepage from V15 into the contaminated upper Grum Creek. The flow from V15 and Grum Creek (GC Weir) are conveyed either via ditch to Moose Pond (inflow measured at V2A), or via the V15/Grum Creek Pumping System to Vangorda Pit, preventing contaminated water from reaching lower Grum Creek. Water quality at V2 represents Grum Creek downstream of the Moose Pond outlet and upstream of the confluence with Vangorda Creek.

5.2 Summary of AMP Event 4 Implementation Protocol

5.2.1 Evolution of AMP Event 4

AMP Event 4 has undergone significant modification since it was first established in 2004. The following is a brief summary of the history of Event 4 that provides a basis for the current AMP Implementation Protocol.

In 2004, as part of the review of the reference period data (1998 – 2002) it was identified that there was a statistically significant increase in sulphate concentrations at V2. In 2000, a rapid increase in sulphate concentrations occurred, with concentrations in 2004 exceeding the proposed 75th percentile threshold value. As a result, two sulphate triggers mechanisms (3

exceedances of the 75th percentile and a significant trend in concentrations) were immediately activated upon implementation of the AMP in July 2004.

To address the immediate trigger activation, an Event 4 response plan was developed and implemented. This response plan outlined additional monitoring and assessment at various locations downstream of the Grum Dump, as well as an interim zinc threshold. Review of water quality data in 2005 at V2 and V2A (Moose Pond) indicated that zinc and sulphate levels had been increasing over several years and that there was significant attenuation of zinc along the surface and subsurface pathways. Recommendations in 2005 resulted in increased monitoring in the area and a change in total zinc threshold from 0.24 mg/L to an interim value of 0.5 mg/L.

In 2007, in response to elevated levels of zinc at V15, a diversion ditch was installed to divert contaminated seepage into an existing ditch and route water from the V15 area away from Grum Creek to Moose Pond. In 2010, a low infiltration cover was installed on the Grum Sulphide Cell to reduce surface and groundwater contamination downgradient of the Grum Dump.

In 2011, the Grum V15 pumping system was installed with a collection sump at the confluence of V15 and Grum Creek to facilitate, when required, the transfer of water from this area to Vangorda Pit. In 2012, two new water quality AMP triggers, at Moose Well No. 2 (SRK05-9) and Moose Seep, were developed for the activation of the Grum V15 pumping system (GEEC, 2012). The proposed triggers consisted of a two-fold assessment, depending on time of year, with the intent to avoid a winter startup of the pumping system. Currently, the Grum V15 pumping system is operated during peak flow events to alleviate the stress that these peak flows have on Moose Pond.

Upon reactivation of the AMP in 2014, it was recommended that a detailed reassessment of the water quality at V2 should be carried out to develop a revised total zinc threshold to replace the interim value of 0.5 mg/L. In the interim, it was recommended that the same zinc threshold value as that applied to Moose Seep and Moose Well No. 2 (SRK05-9) be adopted for V2. Specifically:

- 3 consecutive results > 0.1 mg/L total zinc; or
- Statistically significant trend projects > 0.1 mg/L within 3 years.

The sulphate threshold would remain the same. This recommendation for the interim zinc threshold at V2 has been adopted and subsequently incorporated into the AMP Event 4 Implementation Protocol.

Additionally, the following modifications were included in the 2015 AMP update:

- Sampling frequency at Moose Well No. 2 (SRK05-9) should be increased to twice monthly from May to October and monthly from November to April; and,
- GC Weir (Grum Creek upstream of confluence with V15) should be added to the routine monitoring program (water quality and flow) with the same sample frequency as V15, V2A and V2 (twice monthly from May to October and monthly from November to April).

5.2.2 Current Implementation Protocol

The water quality downgradient of the Grum Rock Dump is currently monitored at the primary AMP trigger locations V2 and Moose Seep. The primary AMP locations for groundwater quality is currently also measured at the Moose Well No. 2 (SRK05-09). Additionally, surface water quality in the area is routinely measured at secondary AMP locations (Moose Pond (V2A), GC Weir and V15). Generally, total metals data are required for AMP analysis, however because

V15 is classified as a seepage location, only dissolved metals data is collected and available for the assessment.

The following is a summary of the AMP assessment criteria for Event 4 (Table 7).

Table 7: Event 4 AMP Assessment Criteria

Indicators	Locations	Thresholds	Frequency
Zn-T and Sulphate	V2	<ul style="list-style-type: none"> 3 consecutive results > 75th percentile of reference period (Zn-T = 0.1 mg/L; sulphate = 567 mg/L); or Statistically significant trend projects > 75th percentile of reference period within 3 years. 	Twice Monthly (May – October) and Monthly (November – April)
Zn-D	Moose Seep and Moose Well No. 2 (SRK05-9)	<ul style="list-style-type: none"> 3 consecutive results > 0.1 mg/L; or Statistically significant trend projects > 0.1 mg/L in the winter season (November to April) of following year. 	Twice Monthly (May – October) and Monthly (November – April)
Zn-D	Moose Seep and Moose Well No. 2 (SRK05-9)	<ul style="list-style-type: none"> 3 consecutive results > 0.1 mg/L; or Statistically significant trend projects > 0.1 mg/L in open water season (May to October) of the following year. 	Twice Monthly (May – October) and Monthly (November – April)
Zn-T Sulphate Mn-T Mg-T Alkalinity Ca-T	GC Weir	None	Twice Monthly (May – October) and Monthly (November – April)
Zn-D Sulphate Mn-D Mg-D Alkalinity Ca-D	V15	None	Twice Monthly (May – October) and Monthly (November – April)
Zn-T Sulphate Mn-T Mg-T Alkalinity Ca-T	V2A	None	Twice Monthly (May – October) and Monthly (November – April)

5.3 Data Review

Assessment under the AMP of the relevant water quality data from V2, Moose Seep, Moose Well No. 2 (SRK05-9), GC Weir, V15 and V2A was carried out using 2015 water quality data. The water quality data from V2 for 2003 to 2015 is presented in Figures 12 and 13. The data for Moose Seep for 2009 to 2015 is presented in Figure 14. The data for Moose Well No. 2 (SRK05-9) for 2009 to 2015 is presented in Figure 15. The results of the Event 4 assessment are summarized in Table 8.

With the exception of one event (July 6, 2015; 0.3 mg/L), the total zinc threshold was not exceeded in 2015 at V2. There is an increasing trend in total zinc concentrations, but it is not significant at this time. Since 2003, sulphate concentrations at V2 have been below the 75th percentile threshold (567 mg/L) on only 3 occasions. Note that there is a decreasing trend in sulphate at V2, though the trend is not statistically significant.

At Moose Seep, the dissolved zinc threshold was not exceeded during either the open water (May to October) or winter seasons (November to April) in 2015. Both seasons currently show an increasing trend in dissolved zinc concentrations, but they are not statistically significant.

Similarly, the dissolved zinc threshold was not exceeded in either the open water or winter season in 2015 at Moose Well No. 2 (SRK05-9). The winter season has a nonsignificant increasing trend in dissolved zinc, while the open water season has a decreasing trend in dissolved zinc.

Of the secondary trigger locations, trend analyses indicate that statistically significant increasing trends only occur at V15 and V2A. At V15, all parameters except manganese are statistically increasing. The V15/Grum Creek Pumping System to Vangorda Pit operated throughout 2015, with the majority occurring between May and November. The V2A (Moose Pond), sulphate, magnesium and calcium concentrations are also statistically increasing. Note that although parameters measured at GC Weir were not statistically increasing, water from Grum Creek has the potential to be a higher loading contributor to Moose Pond than V15 (GEEC 2012). Therefore, the source of increased sulphate concentrations noted at V2 is currently unclear.

Table 8: Summary of AMP Event 4 Assessment

Indicators	Locations	Trigger Activation	Results
Zn-T	V2	No	<ul style="list-style-type: none"> 75th percentile threshold of 0.1 mg/L was not exceeded during three consecutive events in 2015. Increasing non-significant trend in total zinc concentrations.
Sulphate	V2	Yes	<ul style="list-style-type: none"> 75th percentile threshold of 567 mg/L was exceeded during three consecutive events in 2015; concentrations have consistently been greater than the threshold since at least May 2011. Decreasing trend in sulphate concentrations but not statistically significant

Zn-D (Nov - April)	Moose Seep	No	<ul style="list-style-type: none"> 75th percentile threshold of 0.1 mg/L was not exceeded during three consecutive events in 2015. Increasing trend in Zn-D concentrations but not statistically significant.
Zn-D (Nov - April)	Moose Well No. 2	No	<ul style="list-style-type: none"> 75th percentile threshold of 0.1 mg/L was not exceeded during three consecutive events in 2015. Increasing trend in Zn-D concentrations but not statistically significant.
Zn-D (May - Oct)	Moose Seep	No	<ul style="list-style-type: none"> 75th percentile threshold of 0.1 mg/L was not exceeded during three consecutive events in 2015. Increasing trend in Zn-D concentrations but not statistically significant.
Zn-D (May - Oct)	Moose Well No. 2	No	<ul style="list-style-type: none"> 75th percentile threshold of 0.1 mg/L was not exceeded during three consecutive events in 2015. Decreasing trend in Zn-D concentrations.
Zn-T Sulphate Mn-T Mg-T Alkalinity Ca-T	GC Weir	Not Applicable	<ul style="list-style-type: none"> Decreasing trend in Zn-T concentrations but not statistically significant Decreasing trend in sulphate concentrations but not statistically significant Decreasing trend in Mn-T concentrations but not statistically significant Increasing trend in Mg-T concentrations but not statistically significant Increasing trend in alkalinity but not statistically significant Increasing trend in Ca-T concentrations but not statistically significant
Zn-D Sulphate Mn-D Mg-D Alkalinity Ca-D	V15	Not Applicable	<ul style="list-style-type: none"> Statistically significant increasing trend in Zn-D concentrations Statistically significant increasing trend in sulphate concentrations Increasing trend in Mn-D concentrations but not statistically significant Statistically significant increasing trend in Mg-D concentrations Statistically significant increasing trend in alkalinity Statistically significant increasing trend in Ca-D concentrations

Zn-T Sulphate Mn-T Mg-T Alkalinity Ca-T	V2A	Not Applicable	<ul style="list-style-type: none"> • Decreasing trend in Zn-T concentrations but not statistically significant • Statistically significant increasing trend in sulphate concentrations • Increasing trend in Mn-T concentrations but not statistically significant • Statistically significant increasing trend in Mg-T concentrations • Decreasing trend in alkalinity but not statistically significant • Statistically significant increasing trend in Ca-T concentrations
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5.4 Recommendations

Based on the 2015 data review for AMP Event 4, the following recommendations have been made to support the ongoing assessment of AMP triggers at this location:

- As part of the next AMP Protocol update, the dissolved zinc statistically significant trend threshold for Moose Seep and Moose Well No. 2 (SRK05-9) in the winter season as written in the current AMP should be revised to reflect the correct threshold (>0.1 mg/L).
- To delineate the main contributor of sulphate to the water quality downgradient of the Grum Rock Dump (V2 via V2A), a chemical loading exercise should be conducted to determine the percent load derived from GC Weir and V15. Changes to sampling design or mitigative actions can then be appropriately focussed.
- As recommended in 2014, additional monitoring that was previously carried out twice yearly as part of the AMP Event 4 monitoring program (developed by SRK in 2006) be re-instated. This should include sampling in spring and fall (flow and water quality) at the following locations between the Grum Dump and Vangorda Creek:
 - GD05 d/s, located in North Fork Creek downgradient of Grum Dump Toe seepage site SRK-GD05;
 - Sheep Creek,
 - Sweet Creek,
 - WTA02, located on the Grum Dump Toe access road near the upper end of Sheep Creek; and,
 - WGD01, located above Sheep Creek west of Grum Dump.
- The 2014 (SLR) Annual review recommended that to ensure early indication of changes to water quality stemming from seepage and groundwater inflows, the list of indicator parameters for Event 4 should be expanded to include additional key indicator parameters. CH2M Hill (2015) completed this review and recommended that Grum Dump seep should be monitored for magnesium (primary trigger), manganese (primary or secondary), alkalinity (secondary) and calcium (secondary).

6.0 AMP EVENT 5 - DEGRADED WATER QUALITY IN THE NORTH FORK OF ROSE CREEK

6.1 General Description

Water quality in the North Fork Rose Creek (NFRC) can be influenced by waste rock seepage, seepage or overflow from the Zone II Pit, seepage from the disturbed area between the NFRC and the Zone II Pit and the North Fork Rock Drain (NFRD), and contaminated groundwater from the Main/Intermediate Rock Dumps.

The environmental consequence of degraded water quality in the NFRC is the potential exposure of aquatic resources, terrestrial resources and human users of these resources to increased levels of contaminants in the NFRC, Rose Creek, Anvil Creek and possibly the Pelly River.

6.2 Summary of AMP Event 5 Implementation Protocol

6.2.1 Evolution of AMP Event 5

There has been a significant amount of work carried out in relation to AMP Event 5 since the AMP was first implemented in July 2004. In 2006, as part of the 2005 annual review, an assessment was carried out that identified statistically significant seasonal differences in sulphate concentrations at X2 during the AMP reference period (1998 – 2002). In response to this, the AMP threshold value for sulphate was modified to account for lower sulphate levels during open water (May to October) and higher levels during the winter low flow period (November to April).

From 2006 to 2008, AMP triggers for both zinc and sulphate at X2 were repeatedly activated for statistically significant increasing trends and three consecutive results exceeding the threshold values. In response to the continued trigger activation, a detailed assessment was carried out in 2008, which confirmed the presence of highly impacted groundwater in the S-Wells area. The likely source of contaminant loading to this area was identified as the Main and Intermediate Rock Dumps. Ongoing investigation was carried out to delineate the extent of contamination and provide information to support the development of a seepage interception system (SIS). In 2009 the S-Wells SIS was installed and start-up of the system occurred in February 2009. In 2009 and 2010, following review of the SIS operation, the system was upgraded to improve performance. From late 2010 to the fall of 2013, zinc and sulphate levels remained generally stable and at concentrations lower than before the installation of the SIS.

Since the fall of 2013, the increased loading to the NFRC from a source in the NFRD area is dominating the zinc concentrations at X2. In order to adequately assess other potential changes in water quality in the NFRC and delineate potential upstream sources, the AMP Protocol in 2015 was updated to include monthly trend analysis of sulphate and total zinc at locations in NFRC upstream of the NFRD, specifically at stations R10 and R9.

In addition, to ensure early indication of changes to water quality stemming from seepage and groundwater inflows, it was recommended that the list of indicator parameters at X2 be expanded to include additional key indicator parameters. Specifically:

- Magnesium and manganese be added to the primary indicator parameter list at X2; and,
- Alkalinity and calcium be considered as secondary indicator parameters at X2, to support the findings of the primary indicator parameters.

6.2.2 Current Implementation Protocol

Zinc is currently the primary contaminant of concern and zinc, sulphate and alkalinity are the primary indicators of acid rock drainage.

The primary AMP trigger location for Event 5 is surface water quality in NFRC at X2. Trend assessment for AMP Event 5 is carried out using only data collected since the installation and upgrade of the S-Wells SIS: December 2009 onwards. The water quality at X2 is presently overwhelmed by the source loading from the NFRD area. In order to adequately assess other potential changes in water quality in the NFRC and delineate potential upstream sources, monthly trend analysis of indicator parameters at locations in NFRC upstream of the NFRD are also carried out at secondary AMP locations (R10 and R9).

A summary of the current AMP assessment criteria for Event 5 is provided in Table 9.

Table 9: Event 5 AMP Assessment Criteria

Indicators	Locations	Thresholds	Frequency
Zn-T	X2	<ul style="list-style-type: none"> • 3 consecutive results > 75th percentile of reference period (0.06 mg/L); or • Statistically significant trend projects > 75th percentile of reference period within 3 years. 	Monthly
Sulphate	X2	<ul style="list-style-type: none"> • 3 consecutive results > 75th percentile of the open water reference period (14.8 mg/L); or • Statistically significant trend projects > 75th percentile of the open water reference period within 3 years. 	Monthly (May-October)
Sulphate	X2	<ul style="list-style-type: none"> • 3 consecutive results > 75th percentile of the winter reference period (29.5 mg/L); or • Statistically significant trend projects > 75th percentile of the winter reference period within 3 years. 	Monthly (November-April)
Alkalinity	X2	<ul style="list-style-type: none"> • Seasonal statistically significant decreasing trend <ul style="list-style-type: none"> ○ Open Water (May to October) and Winter (November to April) 	Weekly during discharge; otherwise monthly
Mn-T Mg-T Ca-T	X2	<ul style="list-style-type: none"> • Statistically significant increasing trend 	Weekly during discharge; otherwise monthly
Zn-T Sulphate Mn-T Mg-T Alkalinity Ca-T	R9	None	Weekly during discharge; otherwise monthly

Indicators	Locations	Thresholds	Frequency
Zn-T Sulphate Mn-T Mg-T Alkalinity Ca-T	R10	None	Weekly during discharge; otherwise monthly

6.3 Data Review

Assessment under the AMP of the relevant water quality data from X2, R9 and R10 was carried out using the 2015 water quality data. Trend assessment for AMP Event 5 is carried out using only data collected since the installation and upgrade of the S-Wells SIS: December 2009 onwards. The water quality data for X2 for 2003 to 2015 is presented in Figures 16 to 21. The results of the Event 4 assessment are summarized in Table 10.

Total zinc concentrations measured at X2 exceeded the threshold (0.06 mg/L) throughout 2015, and have done so consistently since October 2013. There is a statistically significant increasing trend in total zinc concentrations that is predicted to be greater than the 75th percentile of the reference period in less than three years.

In 2015, the sulphate threshold at X2 was exceeded during the winter season in more than three consecutive months (December 2014 to April 2015). No exceedances in 2015 were measured during the open water season. Assessment of the winter season sulphate concentrations indicates a statistically significant increasing trend with levels above the winter threshold value within three years. During the open water season, a decreasing trend in sulphate is observed but not statistically significant at this time.

Assessment of the winter season alkalinity indicates a statistically significant decreasing trend. The open water season trend in alkalinity is also decreasing but is not statistically significant at this time.

Trend assessment of manganese, magnesium and calcium were also performed for concentrations measured at X2 in 2015. Total magnesium and calcium had non statistically significant decreasing trends, while manganese concentrations are statistically increasing.

Trend analyses indicates that, although there are no significant increasing trends at these two locations, there is an increase in sulphate concentrations in this region of the NFRC. A month by month comparison in concentrations has shown that total zinc, sulphate and total manganese increase substantially between R10 and X2 (Figures 22 to 24) and total zinc concentrations increase substantially between R9 and R10 (Figure 25).

Table 10: Summary of AMP Event 5 Assessment

Indicators	Location	Trigger Activation	Results
Zn-T	X2	Yes	<ul style="list-style-type: none"> • 75th percentile threshold of 0.06 mg/L has been exceeded since November 2013. • Statistically significant increasing trend in total zinc concentrations > 75th percentile of reference period within 3 years.
Sulphate (May - Oct)	X2	No	<ul style="list-style-type: none"> • 75th percentile threshold of 14.8 mg/L was not exceeded for three consecutive months in 2015. • Decreasing trend in sulphate concentrations but not statistically significant.
Sulphate (Nov - April)	X2	Yes	<ul style="list-style-type: none"> • 75th percentile threshold of 29.5 mg/L was exceeded for three consecutive months (December 2014 – April 2015). • Statistically significant increasing trend in sulphate concentrations > 75th percentile of reference period within 3 years.
Alkalinity (May - Oct)	X2	No	<ul style="list-style-type: none"> • Decreasing trend in alkalinity but not statistically significant.
Alkalinity (Nov - April)	X2	Yes	<ul style="list-style-type: none"> • Statistically significant decreasing trend in alkalinity.
Mn-T Mg-T Ca-T	X2	Yes - Mn-T No - Mg-T and Ca-T	<ul style="list-style-type: none"> • Statistically significant increasing trend in Mn-T concentrations • Decreasing non significant trend in Mg-T concentrations • Decreasing non significant trend in Ca-T concentrations
Zn-T Sulphate Mn-T Mg-T Alkalinity Ca-T	R9	Not Applicable	<ul style="list-style-type: none"> • Decreasing trend in Zn-T concentrations but not statistically significant • Increasing trend in sulphate concentrations but not statistically significant • Decreasing trend in Mn-T concentrations but not statistically significant • Decreasing trend in Mg-T concentrations but not statistically significant • Decreasing trend in alkalinity but not statistically significant • Decreasing trend in Ca-T concentrations but not statistically significant

Indicators	Location	Trigger Activation	Results
Zn-T Sulphate Mn-T Mg-T Alkalinity Ca-T	R10	Not Applicable	<ul style="list-style-type: none"> • Decreasing trend in Zn-T concentrations but not statistically significant • Increasing trend in sulphate concentrations but not statistically significant • Decreasing trend in Mn-T concentrations but not statistically significant • Decreasing trend in Mg-T concentrations but not statistically significant • Decreasing trend in alkalinity but not statistically significant • Decreasing trend in Ca-T concentrations but not statistically significant

6.4 Recommendations

Based on the 2015 data review for AMP Event 5, the following recommendations were made to support the ongoing assessment of AMP triggers at this location:

- Due to the seasonal trends exhibited at X2, we recommend that concentrations of manganese, magnesium and calcium be evaluated on a seasonal basis (open water and winter), similar to sulphate and alkalinity.
- Currently the water quality at X2 is being overwhelmed by the source loading from the NFRD area. In order to adequately assess other potential changes in water quality in the NFRC and delineate potential upstream sources it is recommended an assessment of other inflows to NFRC upstream of the NFRD, such as seep monitoring locations and groundwater wells, be evaluated for trends in total zinc, sulphate and other acid rock drainage indicator parameters including seepage and groundwater data from the contributing areas upstream of the NFRD. The specific locations to be included in this assessment should be determined in consultation with members of the Project Design Team (CH2M Hill) responsible for the seepage and groundwater assessment at the site. This will provide for an evaluation of other potential sources of loading to NFRC that may be masked by the inflow from the NFRD area.

7.0 REFERENCES

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Figure 1: Sulphate Concentrations Measured at V8 (2003 to 2015)

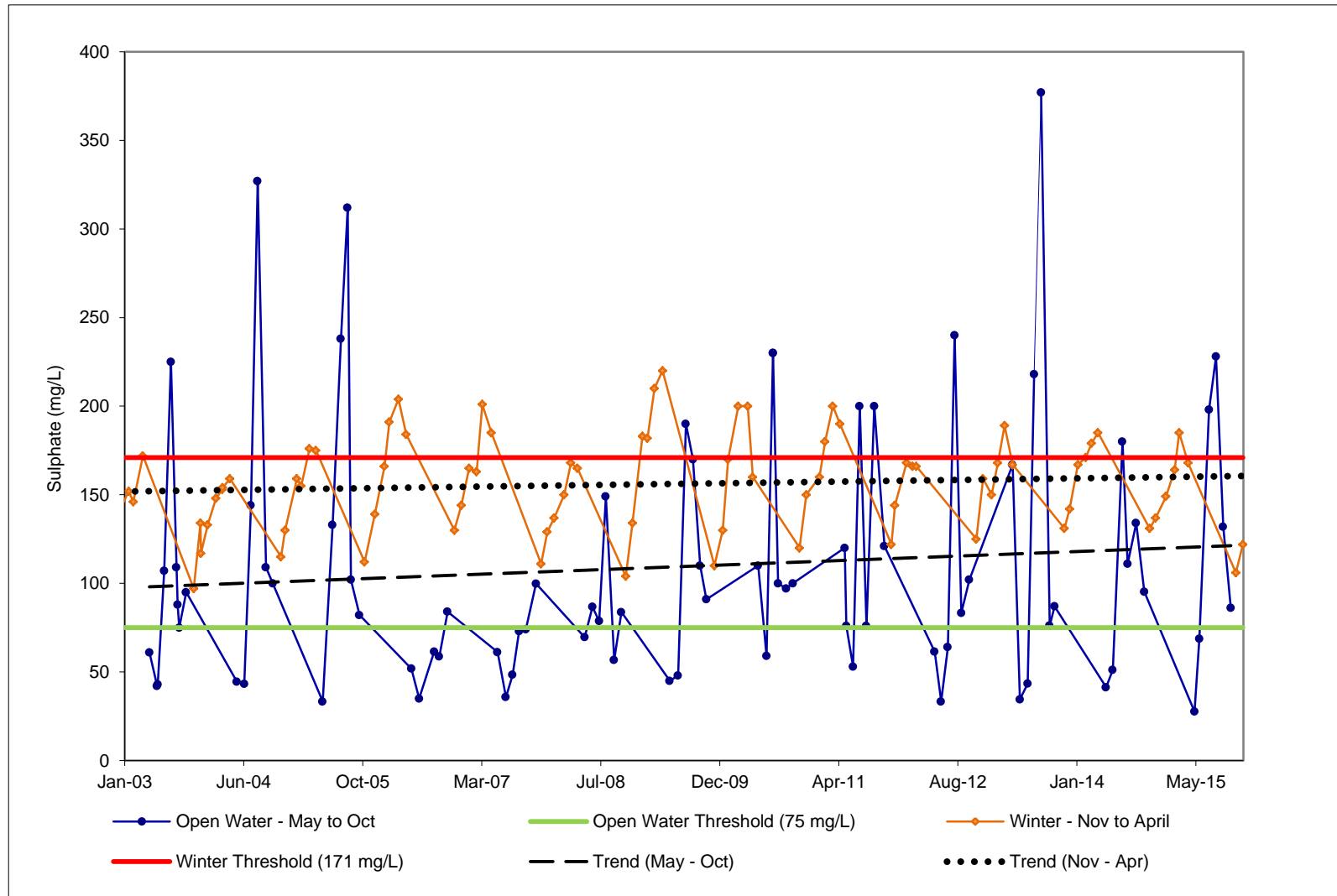


Figure 2: Total Suspended Solids Concentrations Measured at V8 (2003 to 2015)

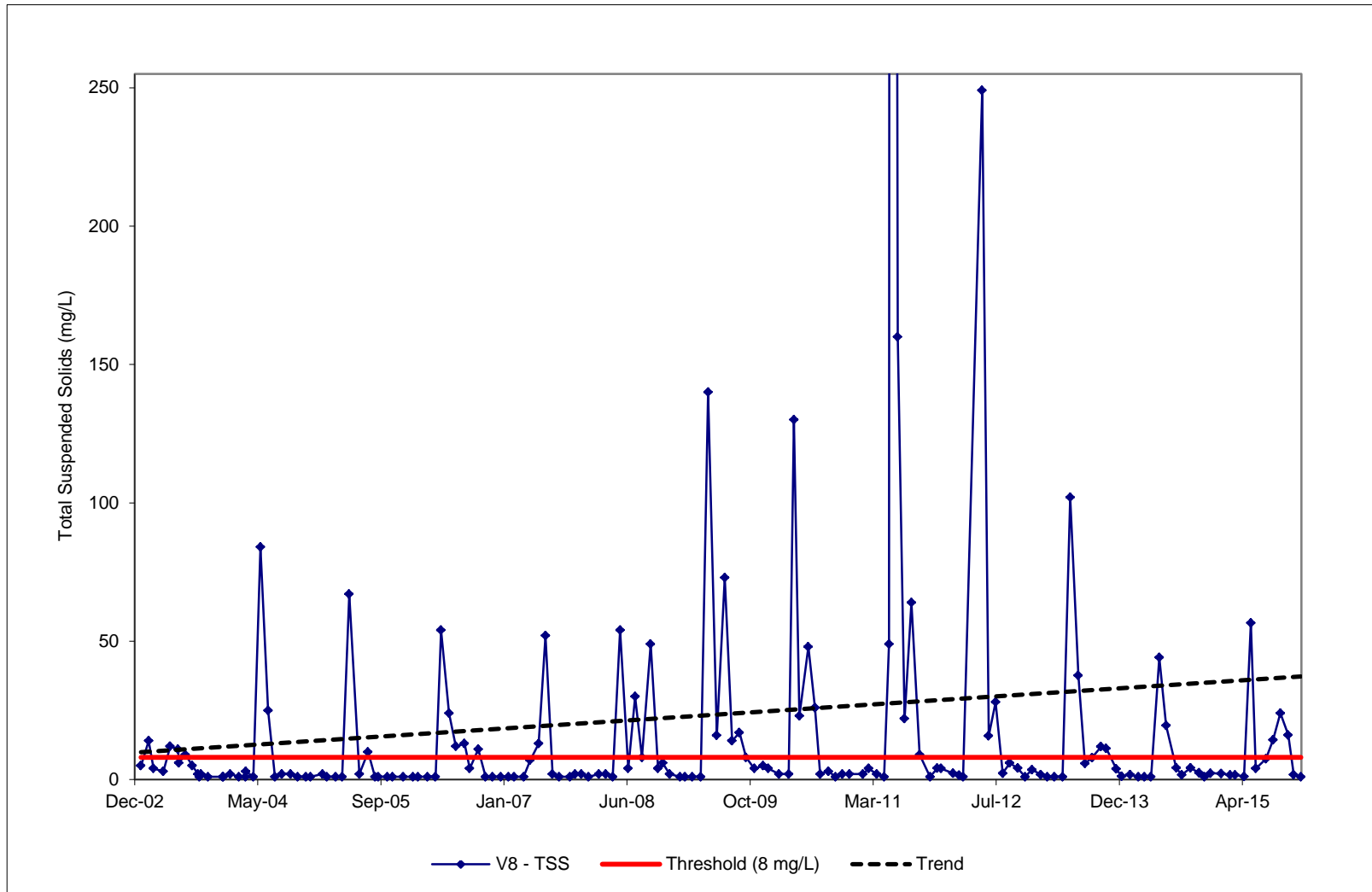


Figure 3: Total Zinc Concentrations Measured at V8 (2003 to 2015)

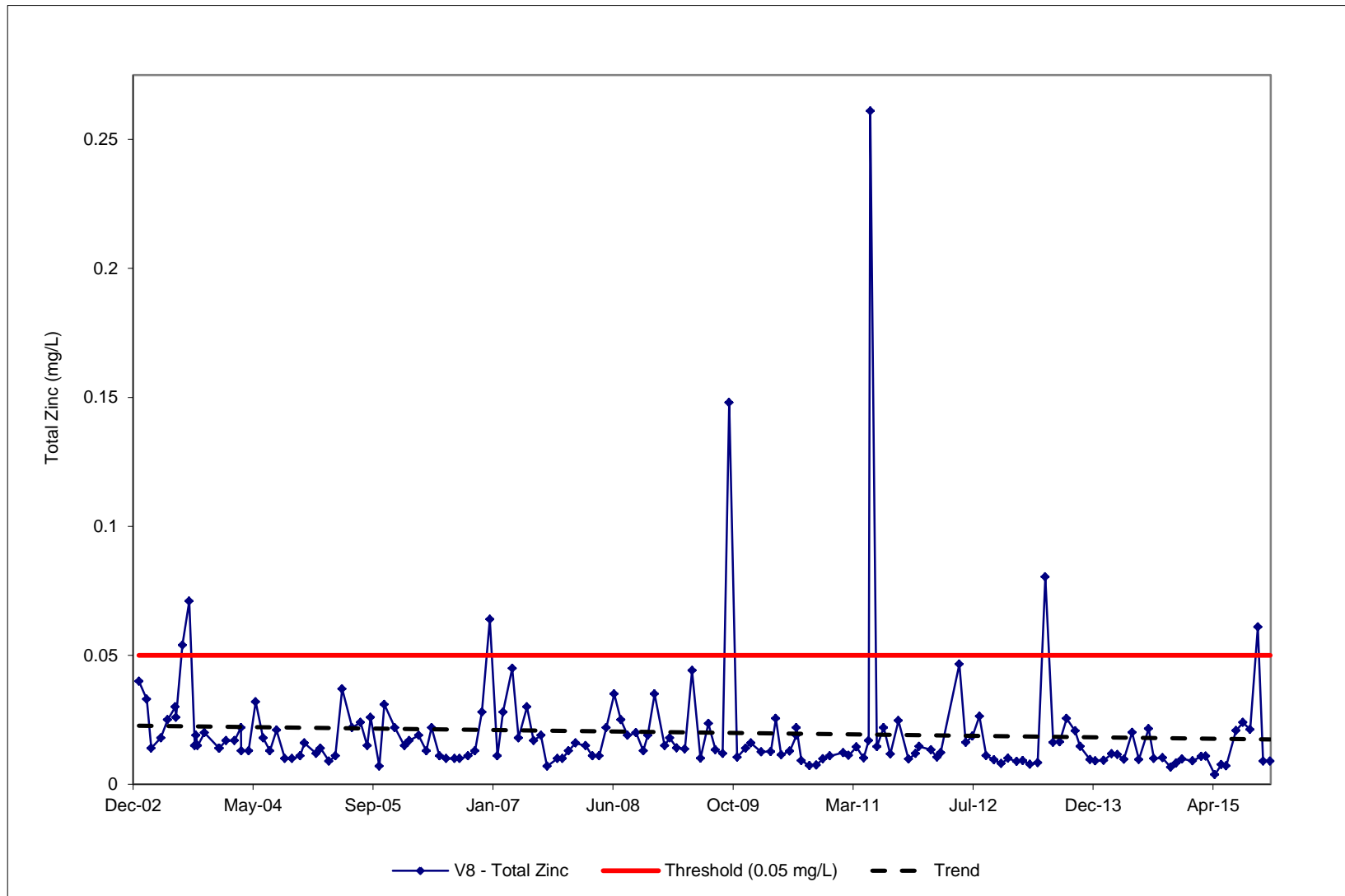


Figure 4: Sulphate Concentrations Measured at X14 (2003 to 2015)

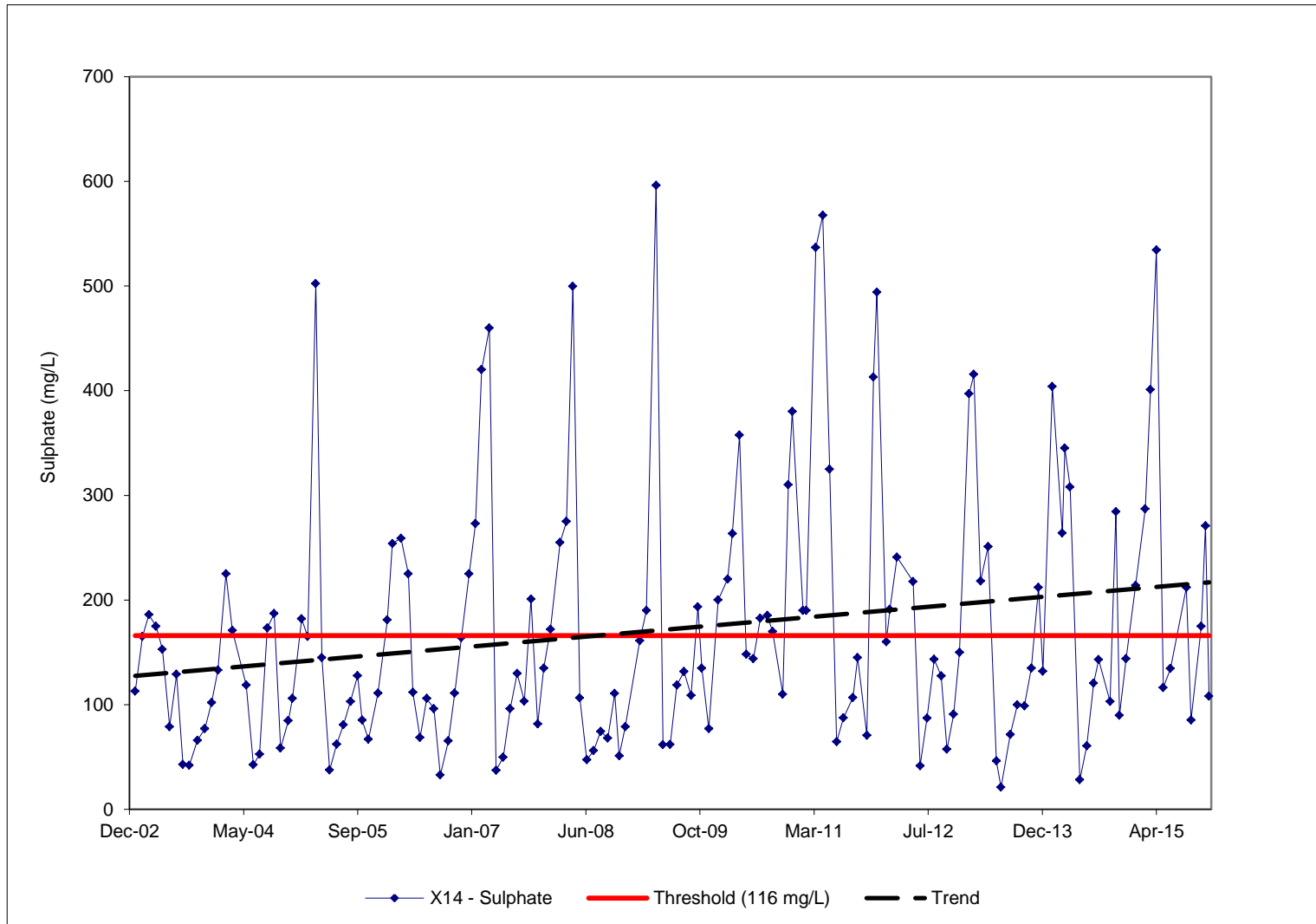


Figure 5: Total Zinc Concentrations Measured at X14 (2003 to 2015)

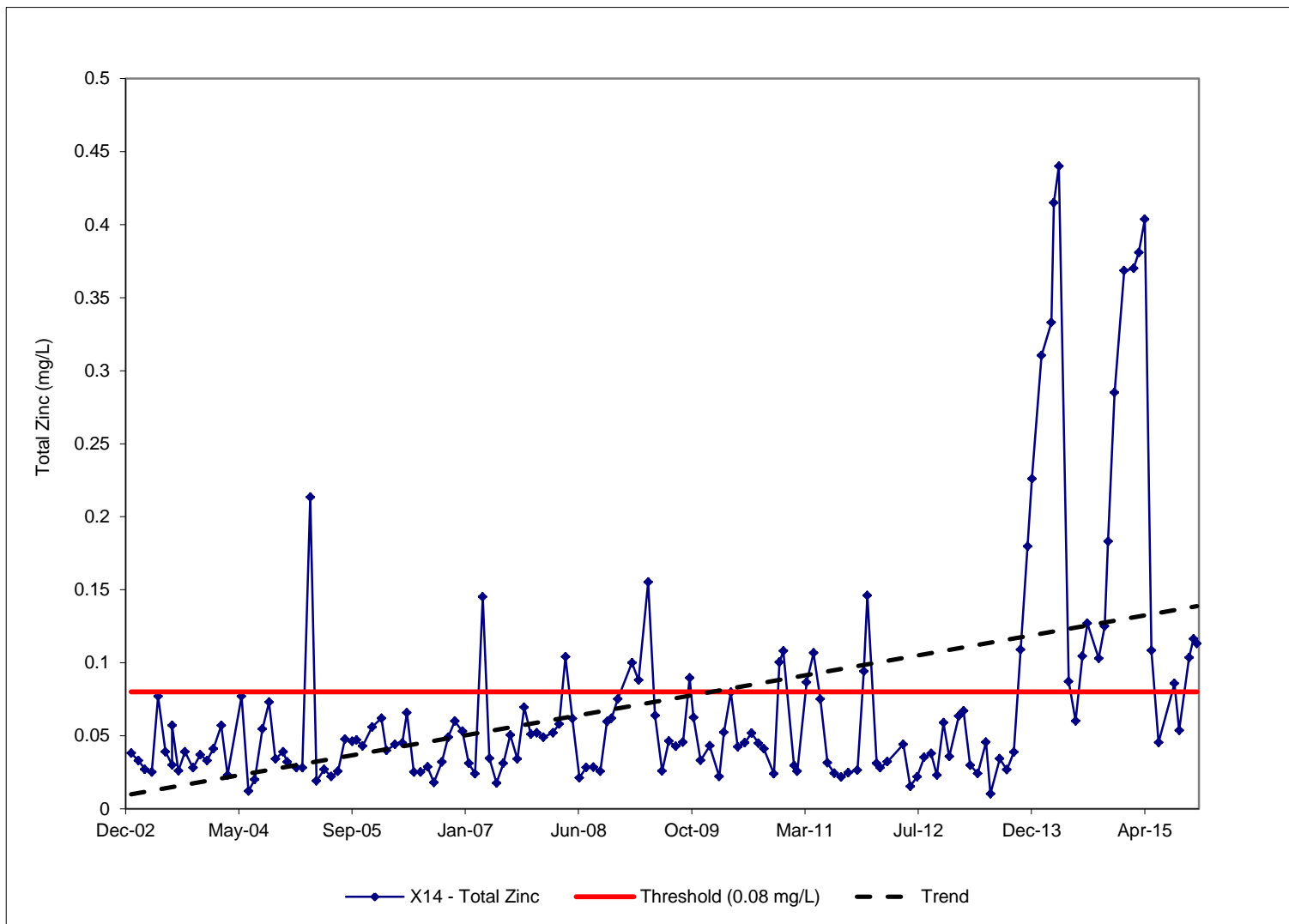


Figure 6: Alkalinity Measured at X14 (2005 to 2015)

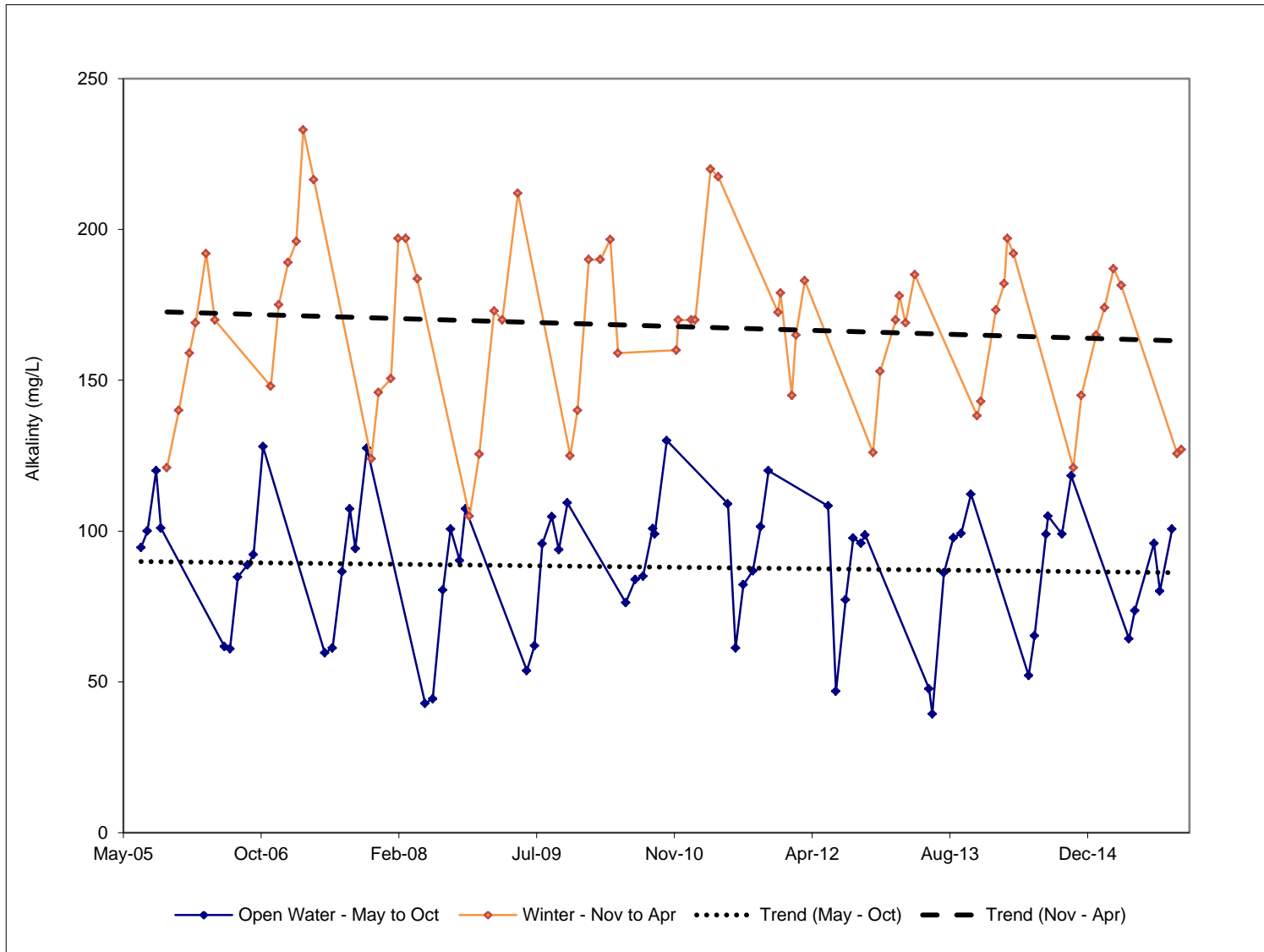


Figure 7: Total Manganese Concentrations Measured at X14 (2003 to 2015)

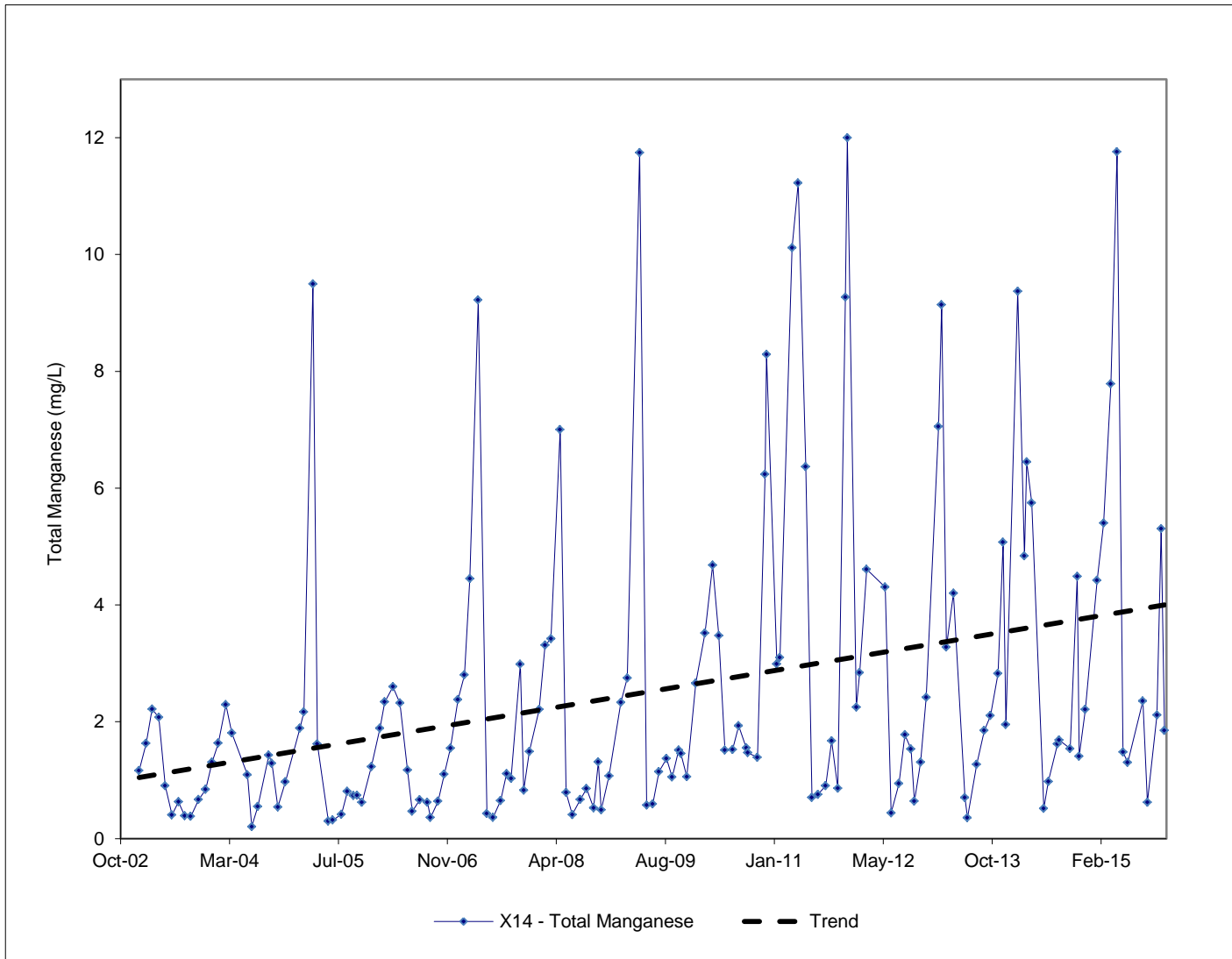


Figure 8: Total Magnesium Concentrations Measured at X14 (2003 to 2015)

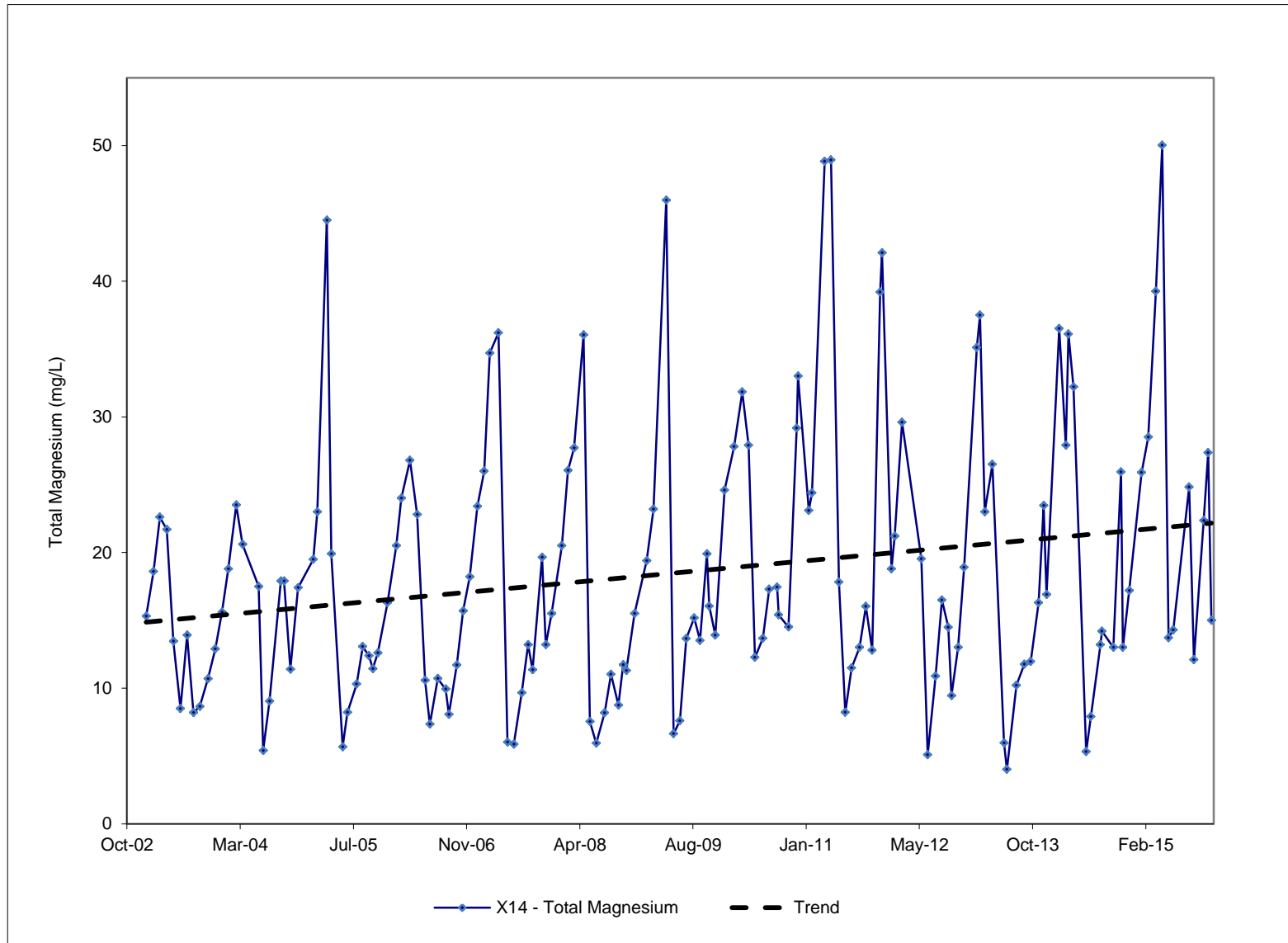


Figure 9: Total Calcium Concentrations Measured at X14 (2003 to 2015)

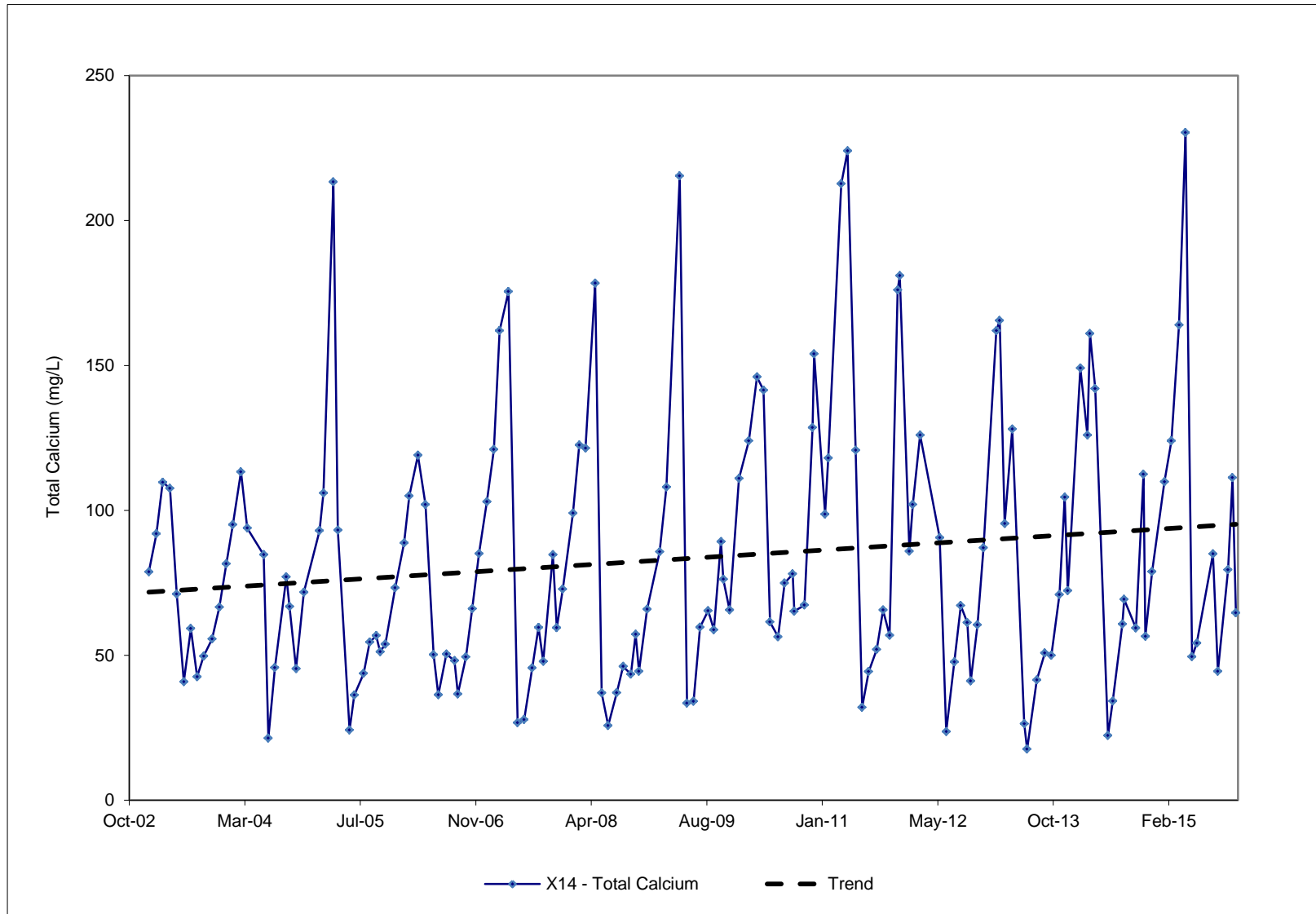


Figure 10: Sulphate Concentrations Measured at X10, X13 and X14 (2002 to 2015)

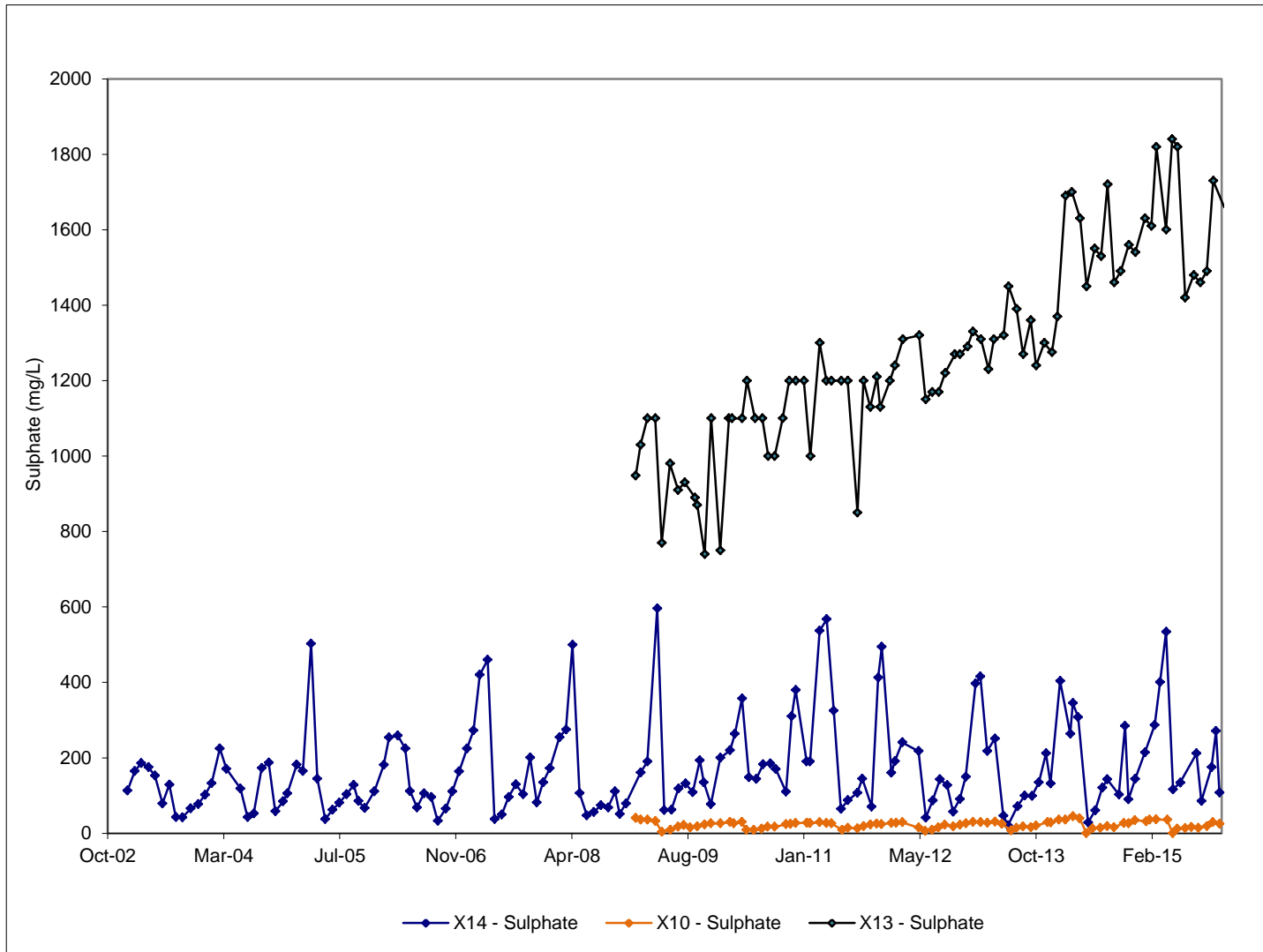


Figure 11: Total and Dissolved Zinc Concentrations Measured at X10, X13 and X14 (2009 to 2015)

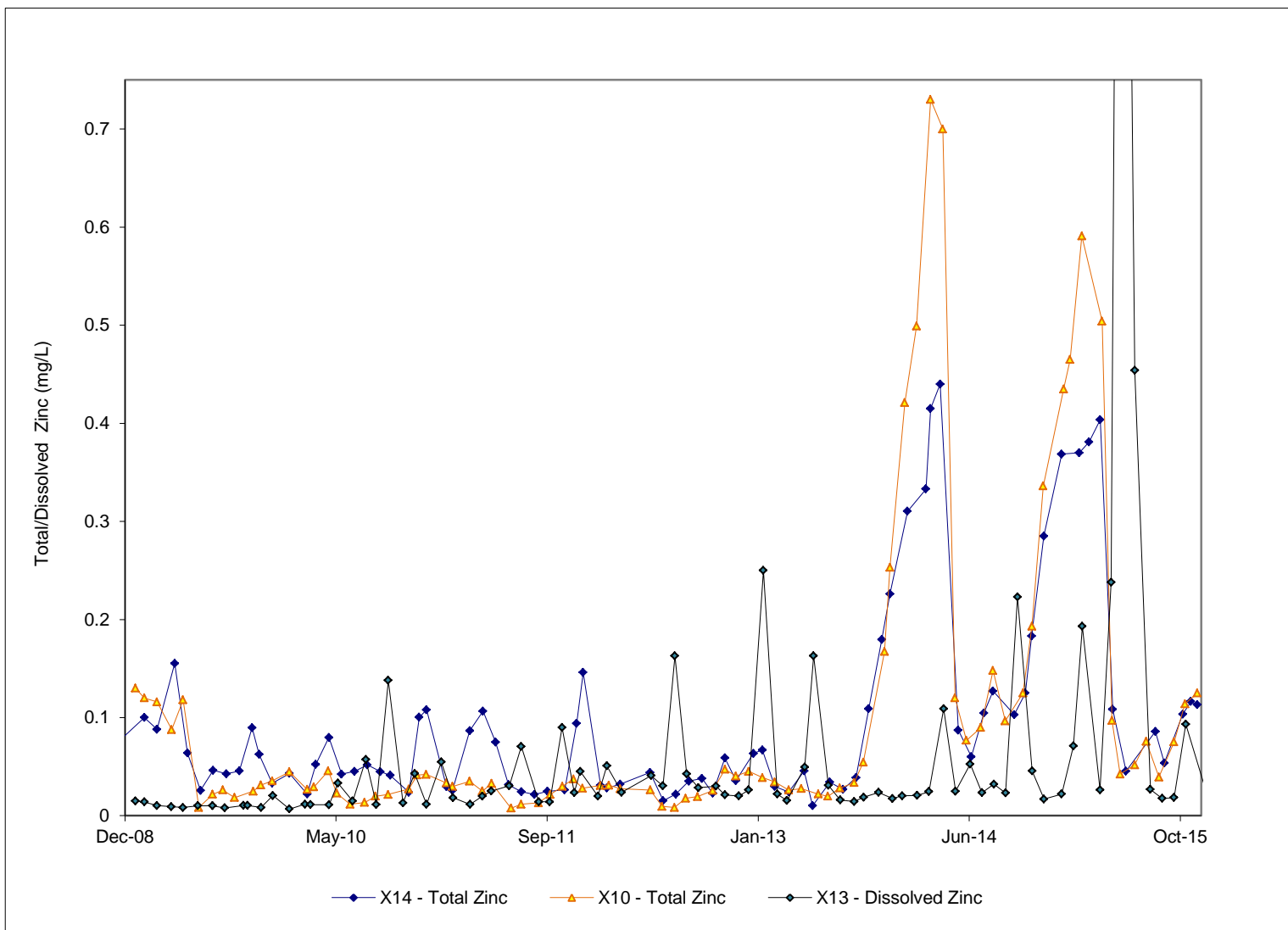


Figure 12: Total Zinc Concentrations Measured at V2 (2003 to 2015)

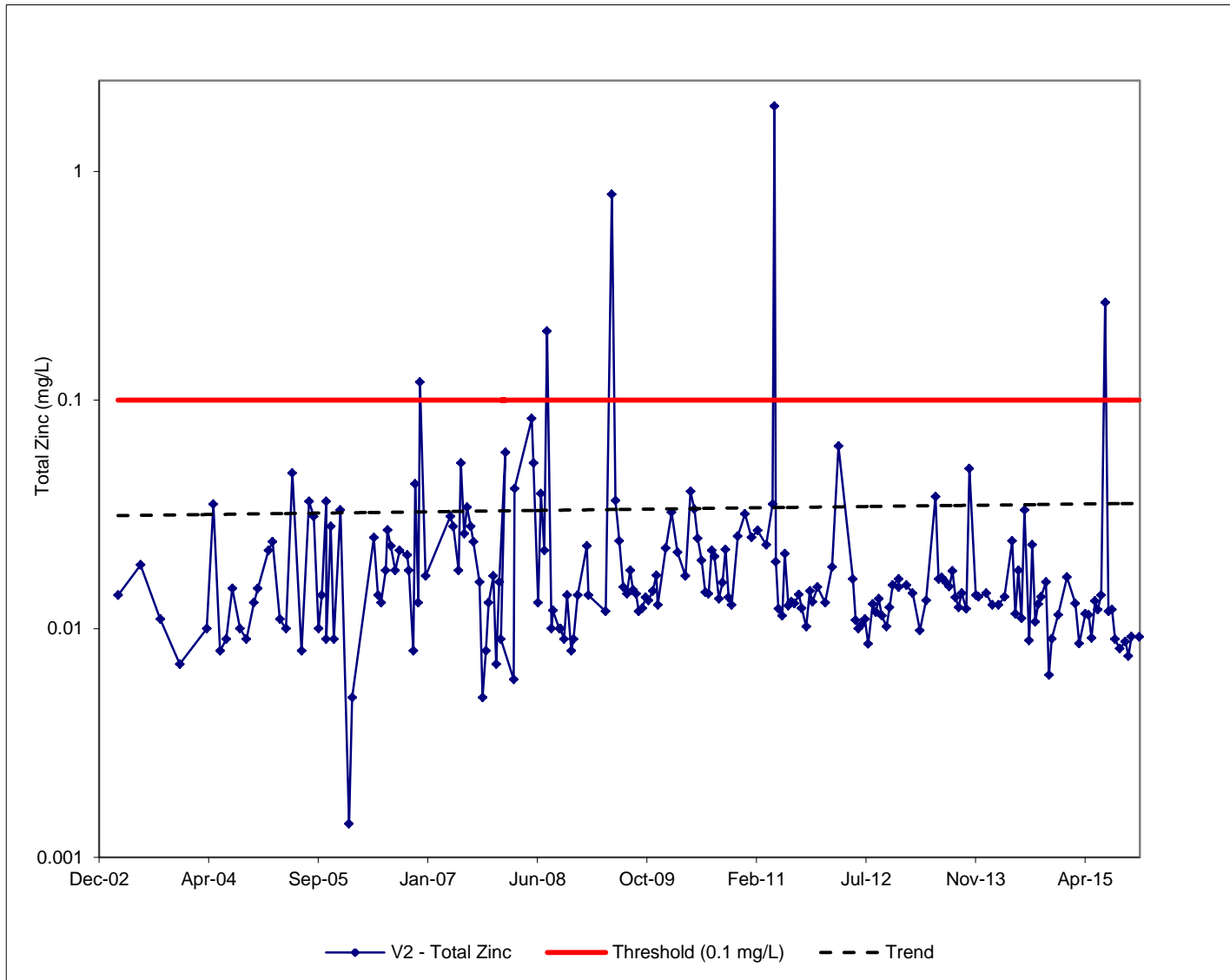


Figure 13: Sulphate Concentrations Measured at V2 (2003 to 2015)

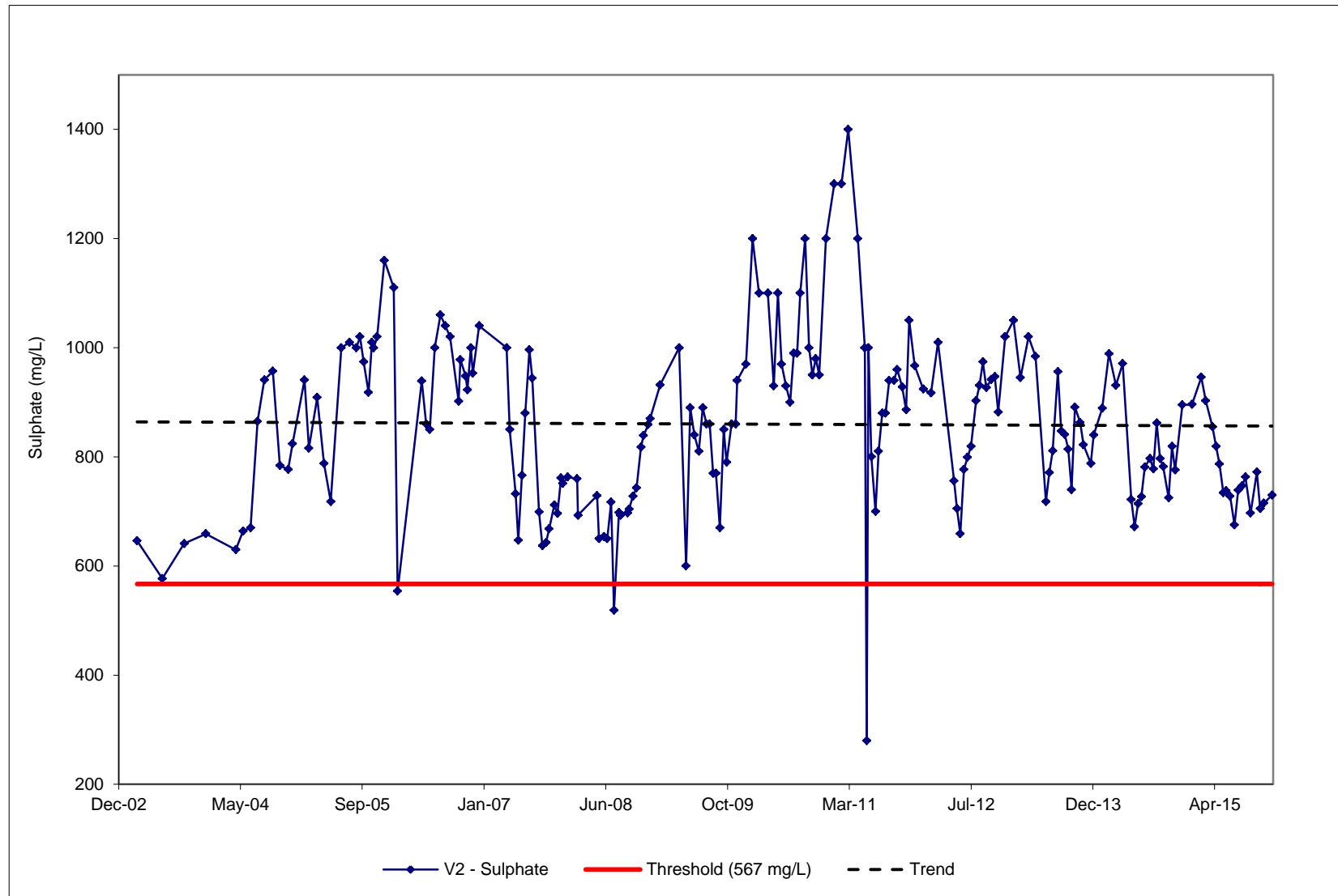


Figure 14: Dissolved Zinc Concentrations Measured at Moose Seep (2009 to 2015)

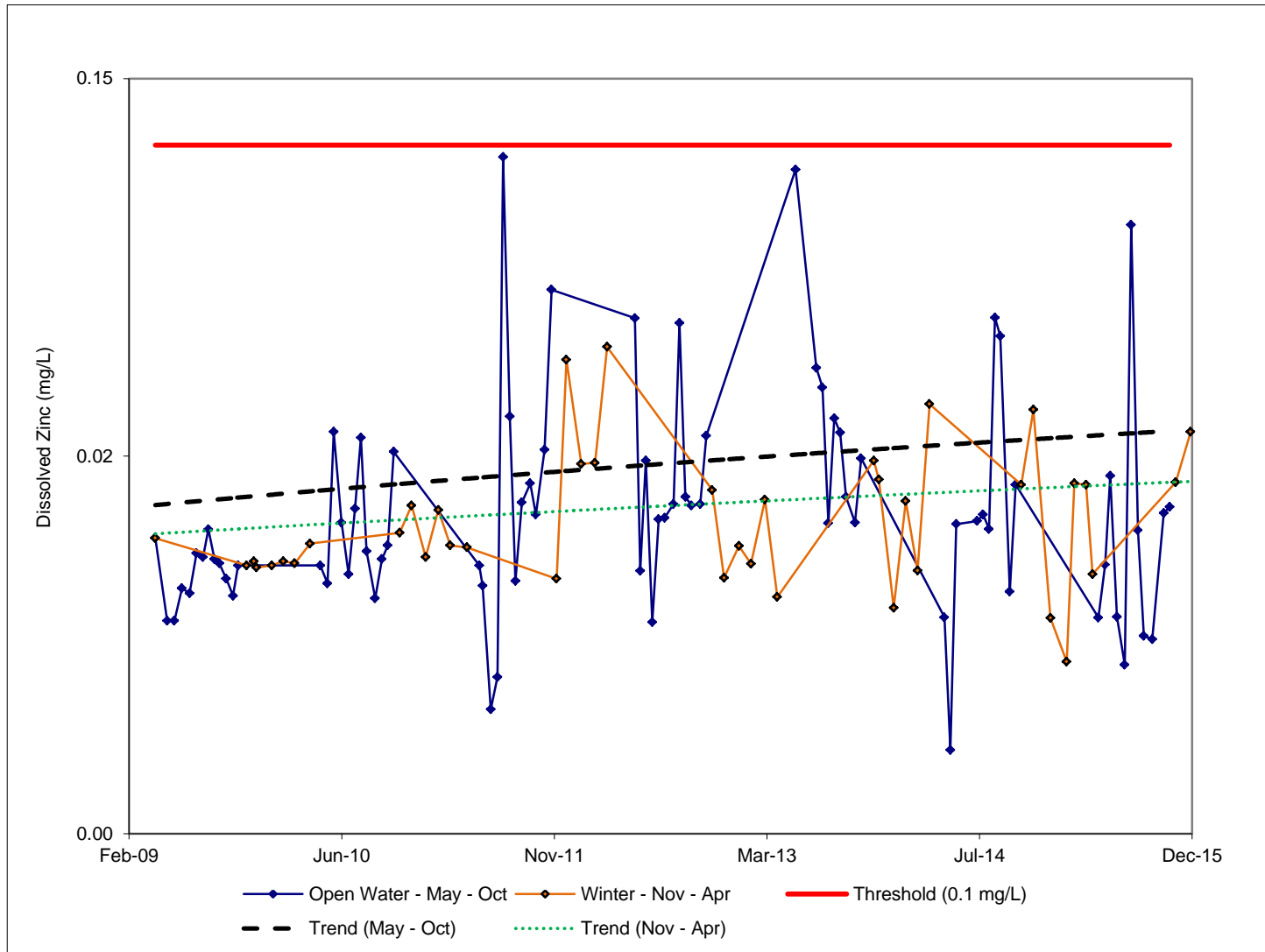


Figure 15: Dissolved Zinc Concentrations Measured at Moose Well No. 2 (SRK05-9) (2006 to 2015)

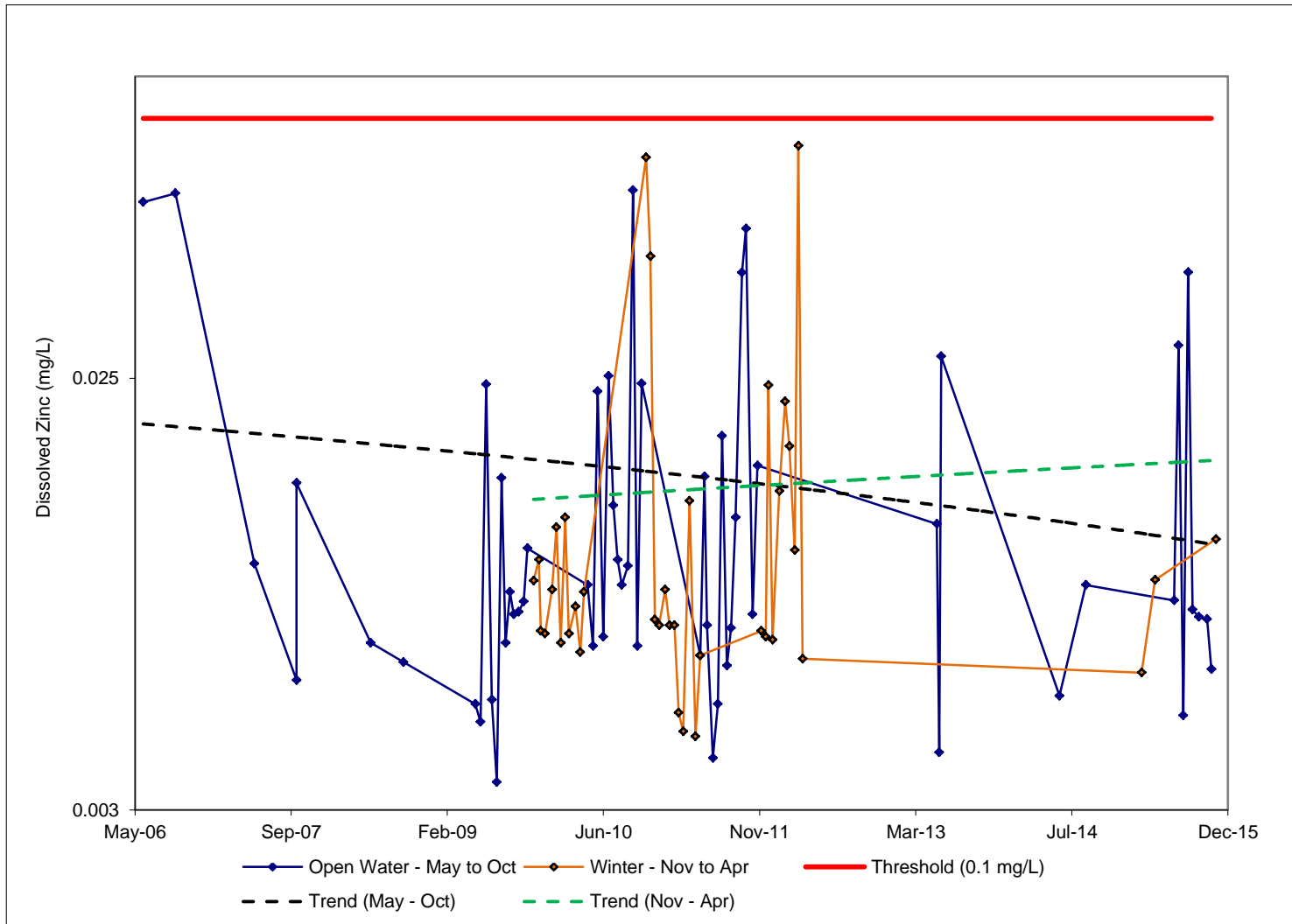


Figure 16: Total Zinc Concentrations Measured at X2 (2003 to 2015)

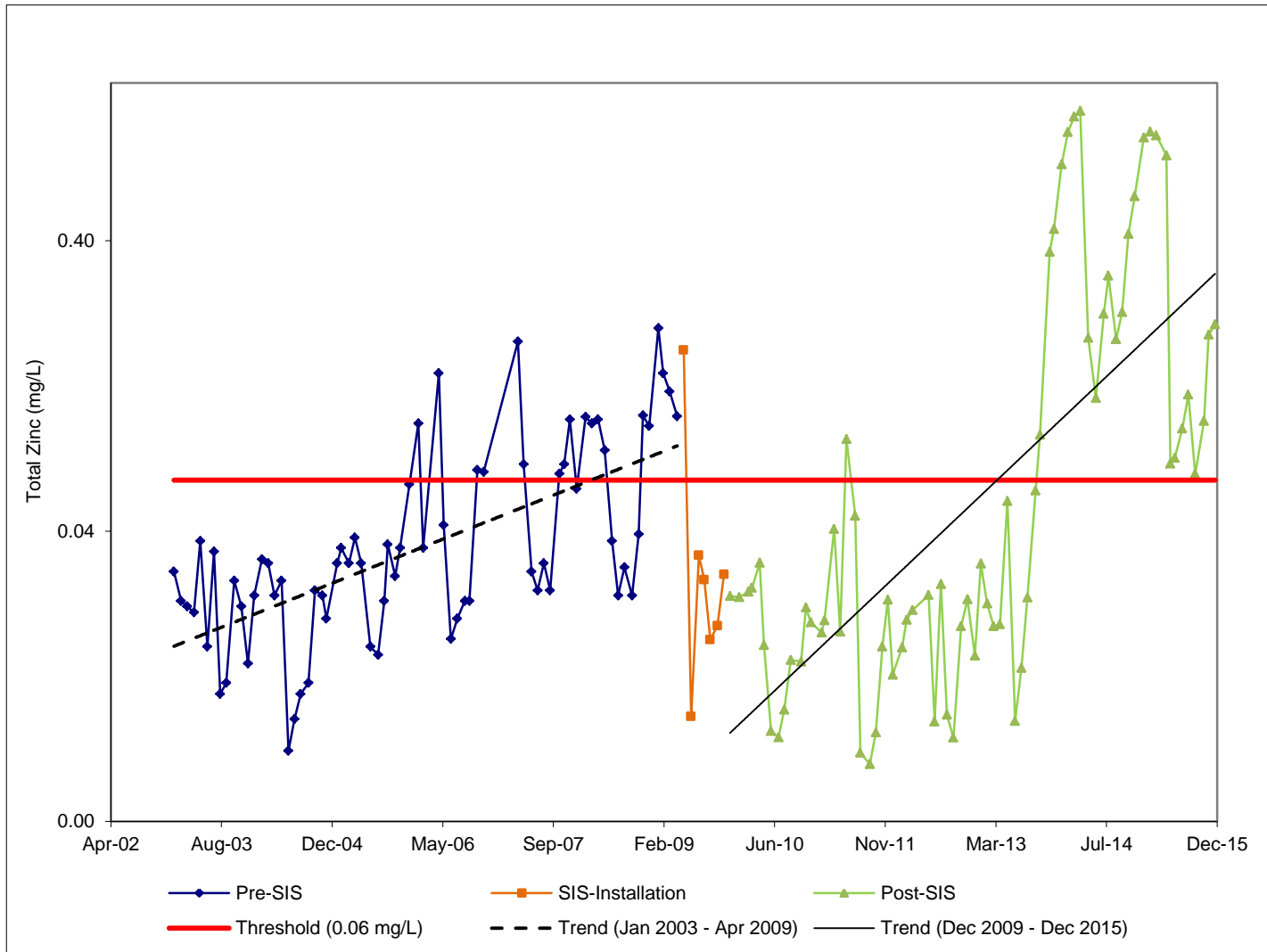


Figure 17: Sulphate Concentrations Measured at X2 (2003 to 2015)

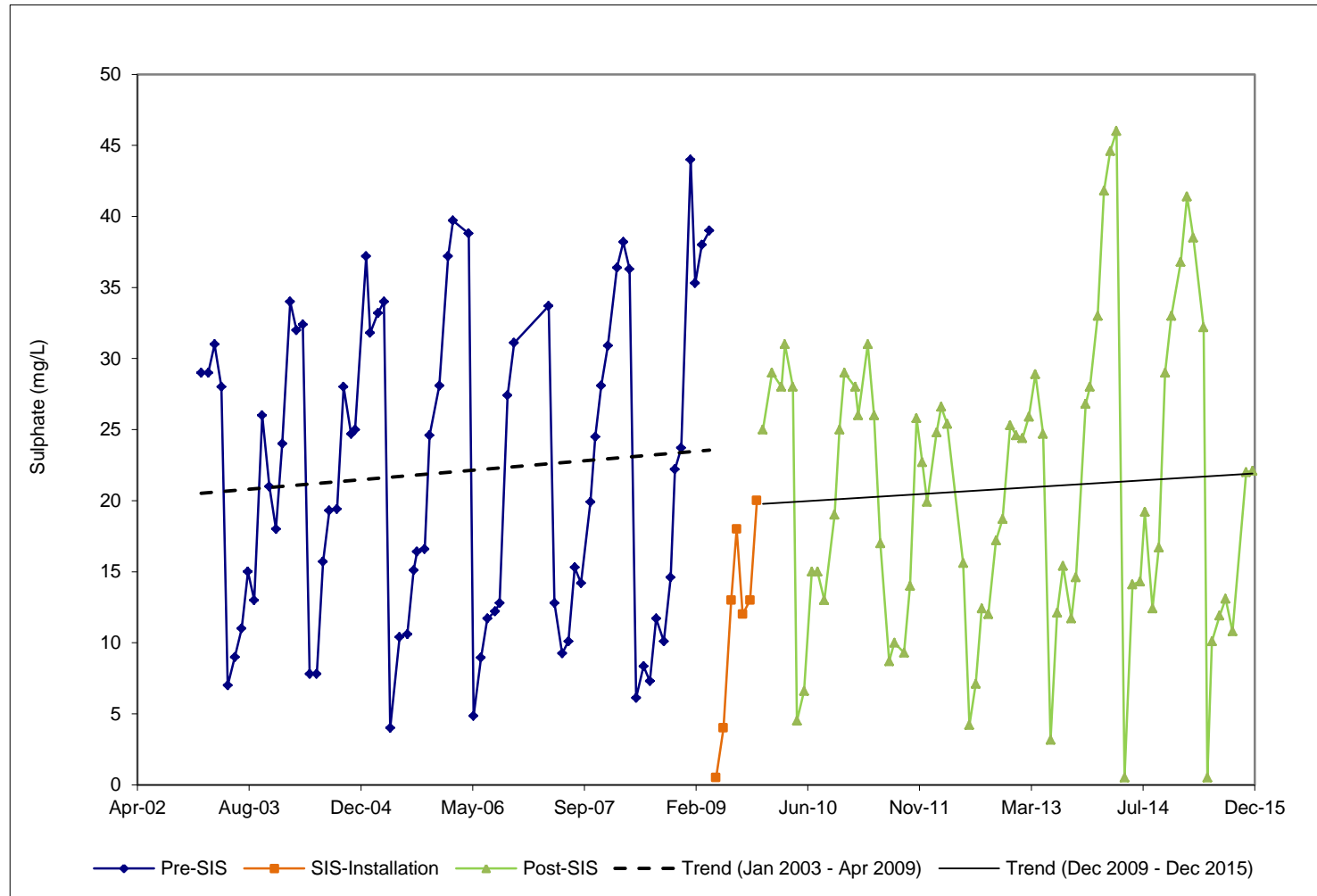


Figure 18: Alkalinity Measured at X2 (2008 to 2015)

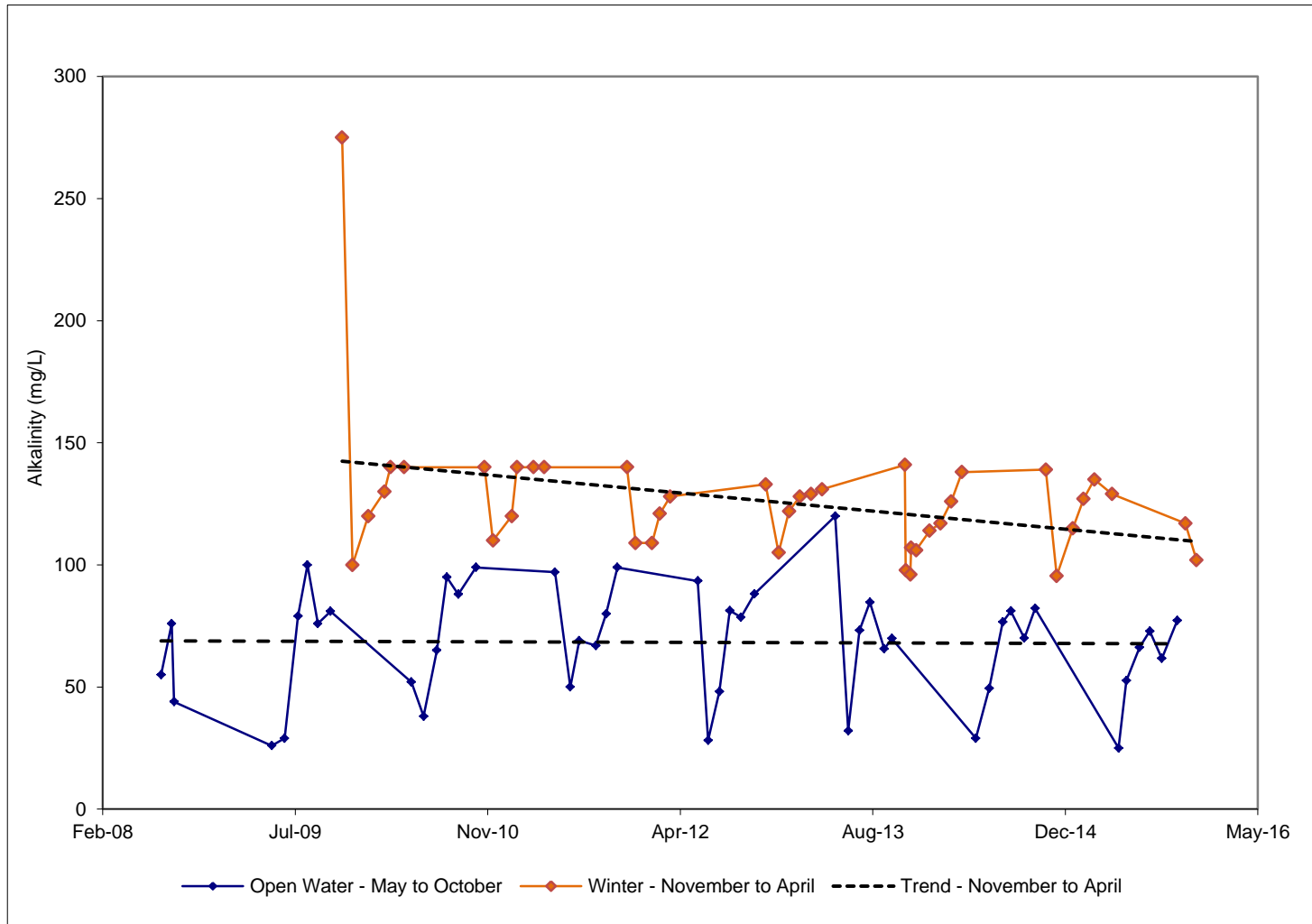


Figure 19: Total Manganese Concentrations Measured at X2 (2003 to 2015)

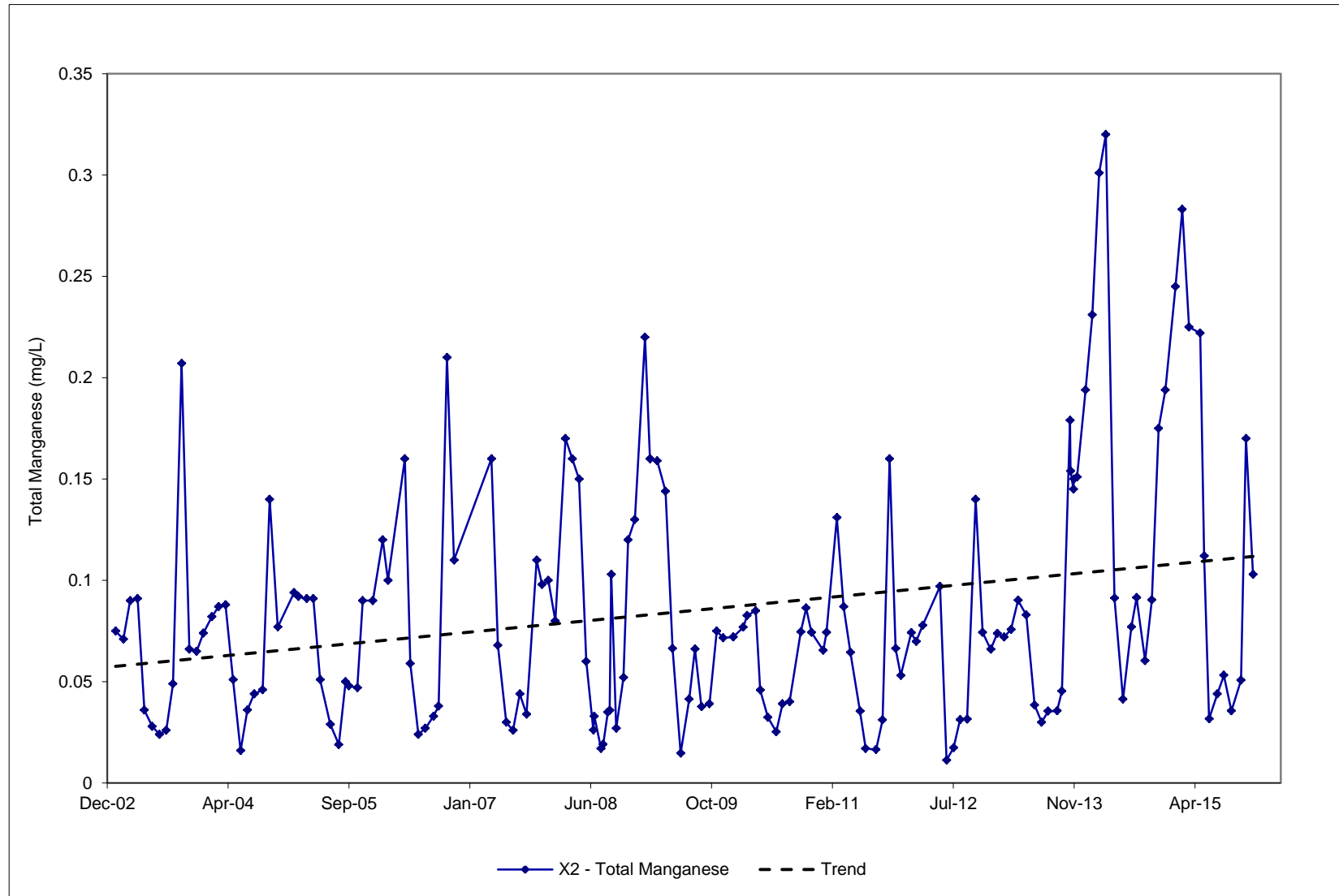


Figure 20: Total Magnesium Concentrations Measured at X2 (2003 to 2015)

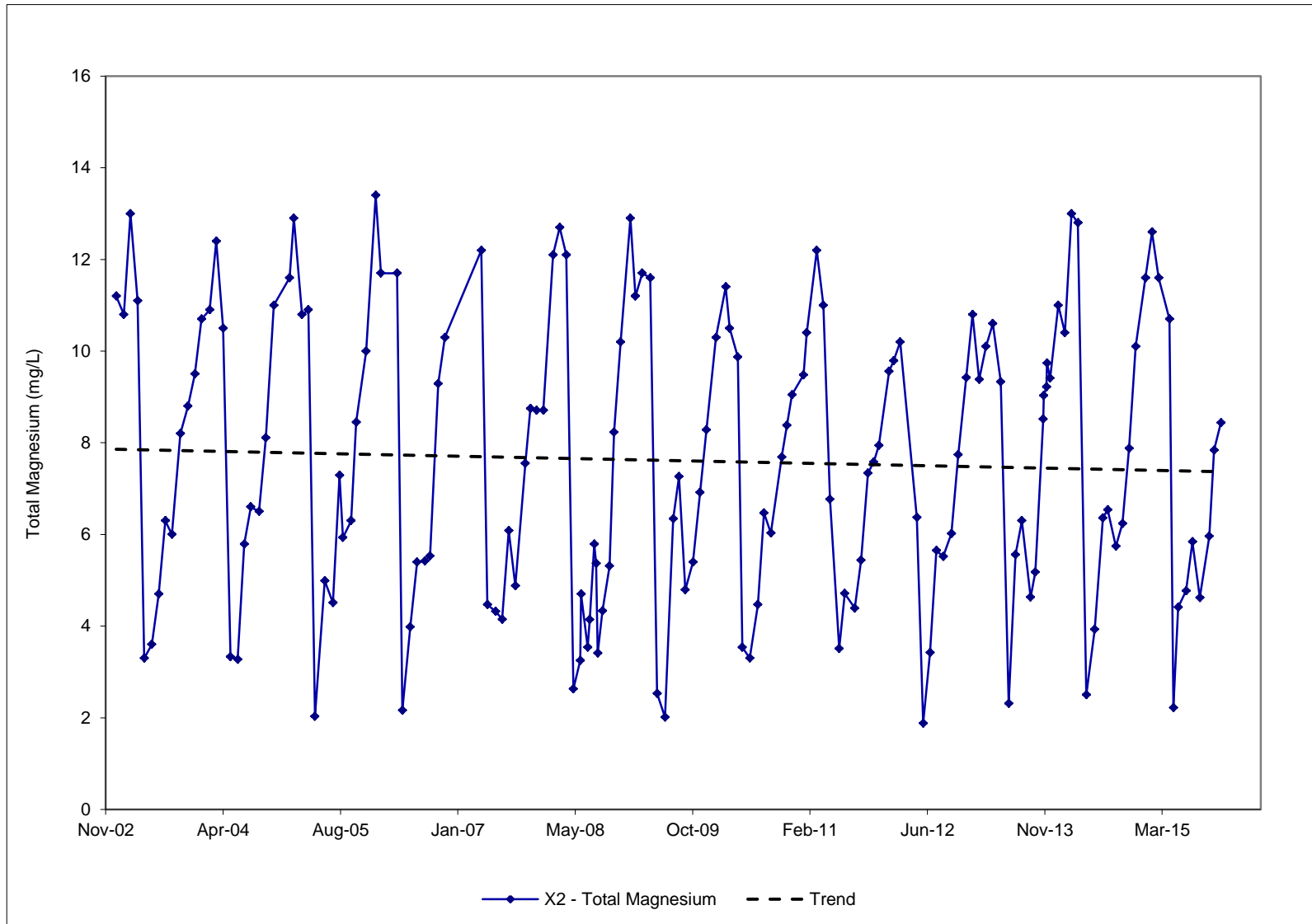


Figure 21: Total Calcium Concentrations Measured at X2 (2003 to 2015)

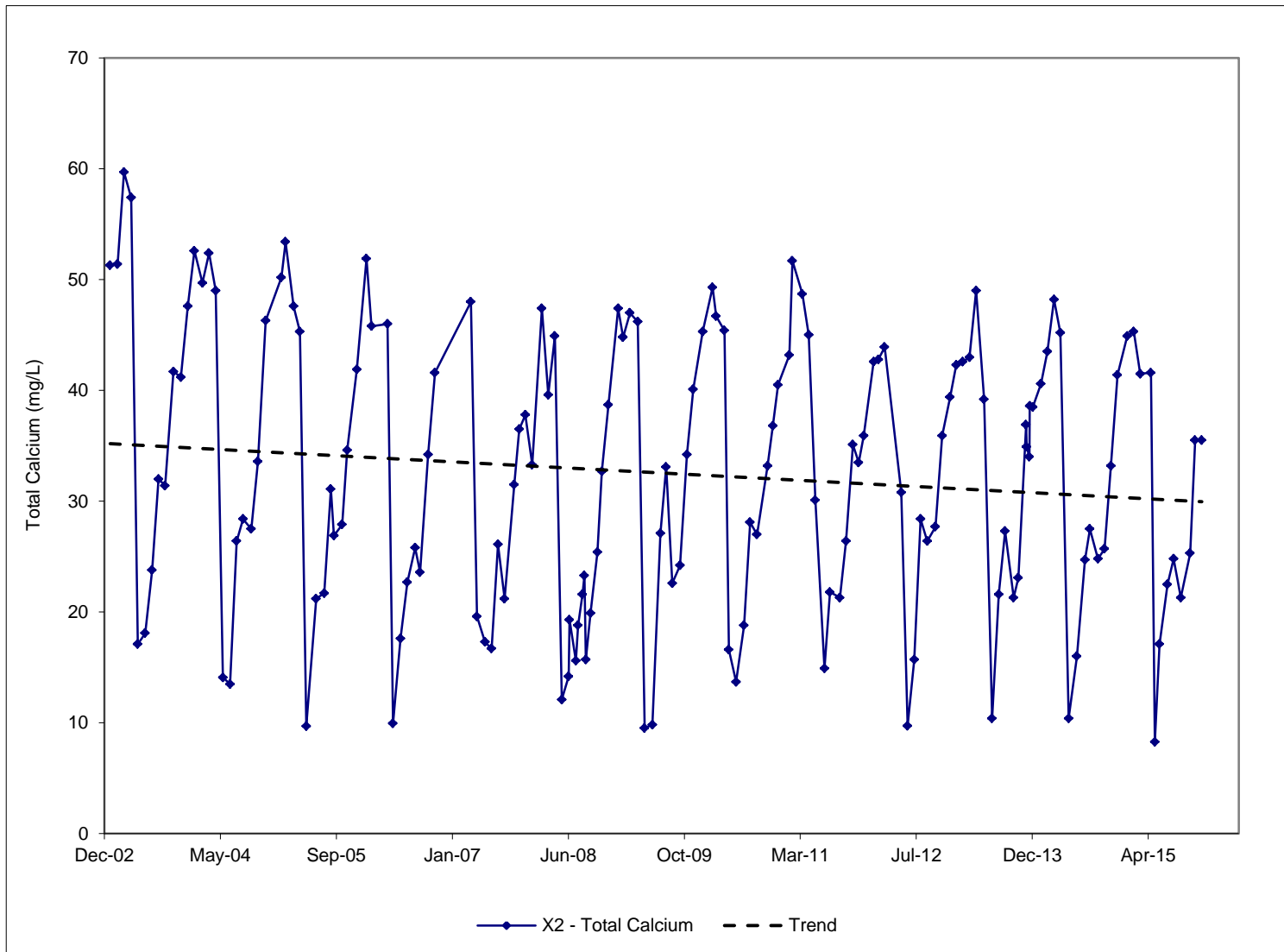


Figure 22: Total Zinc Concentrations Measured at X2 and R10 (2009 to 2015)

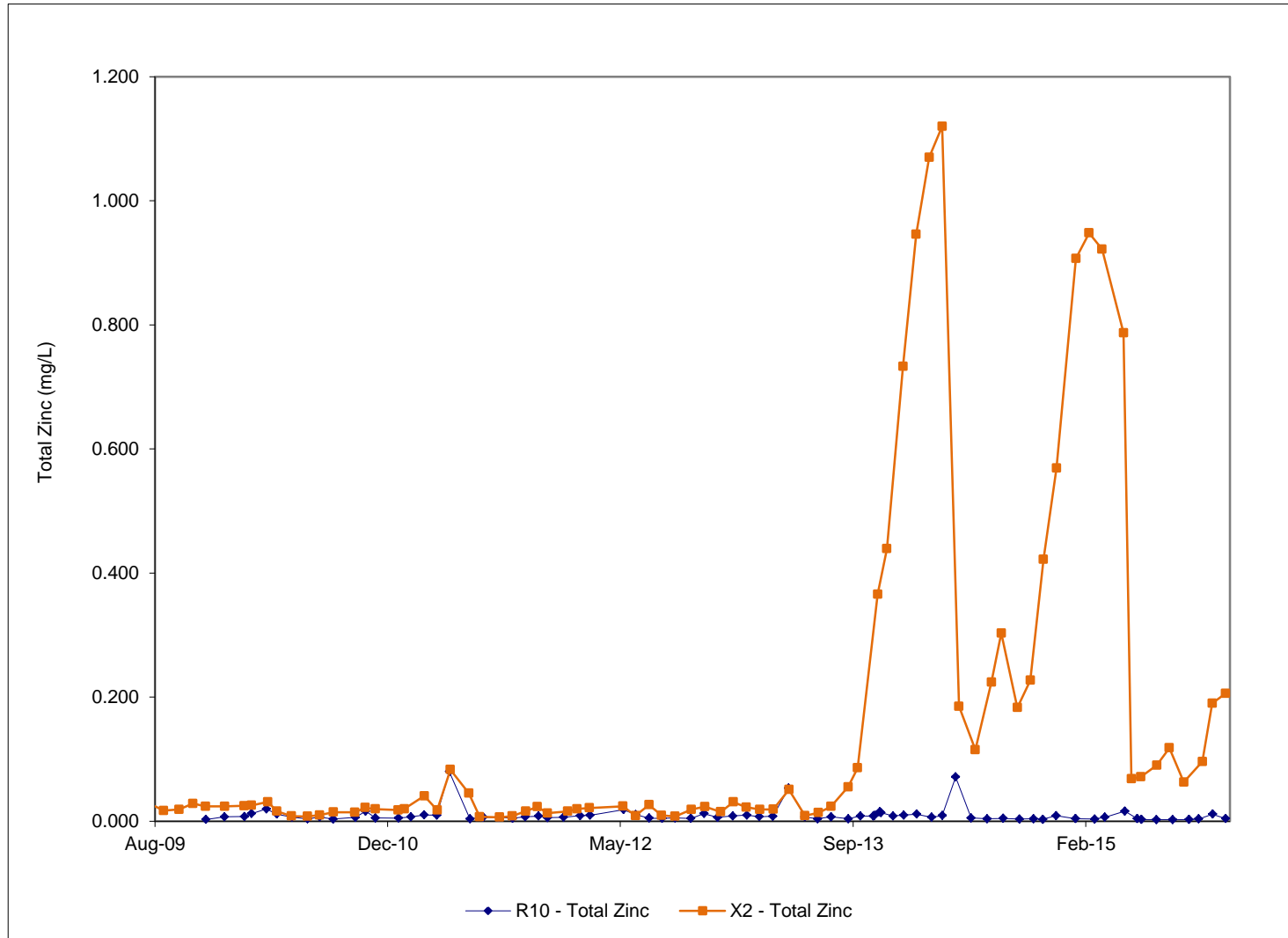


Figure 23: Sulphate Concentrations Measured at X2 and R10 (2009 to 2015)

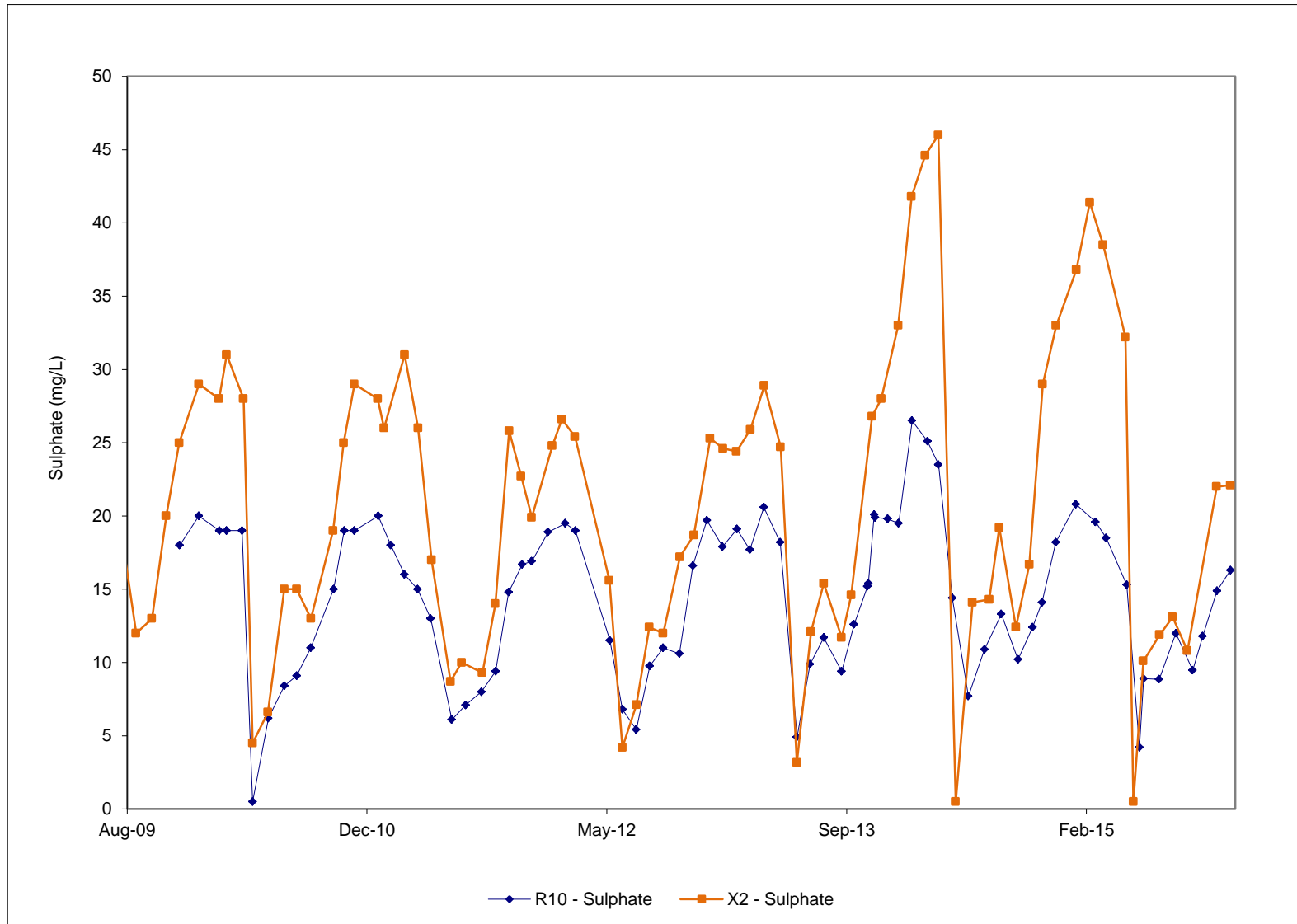


Figure 24: Total Manganese Concentrations Measured at X2 and R10 (2009 to 2015)

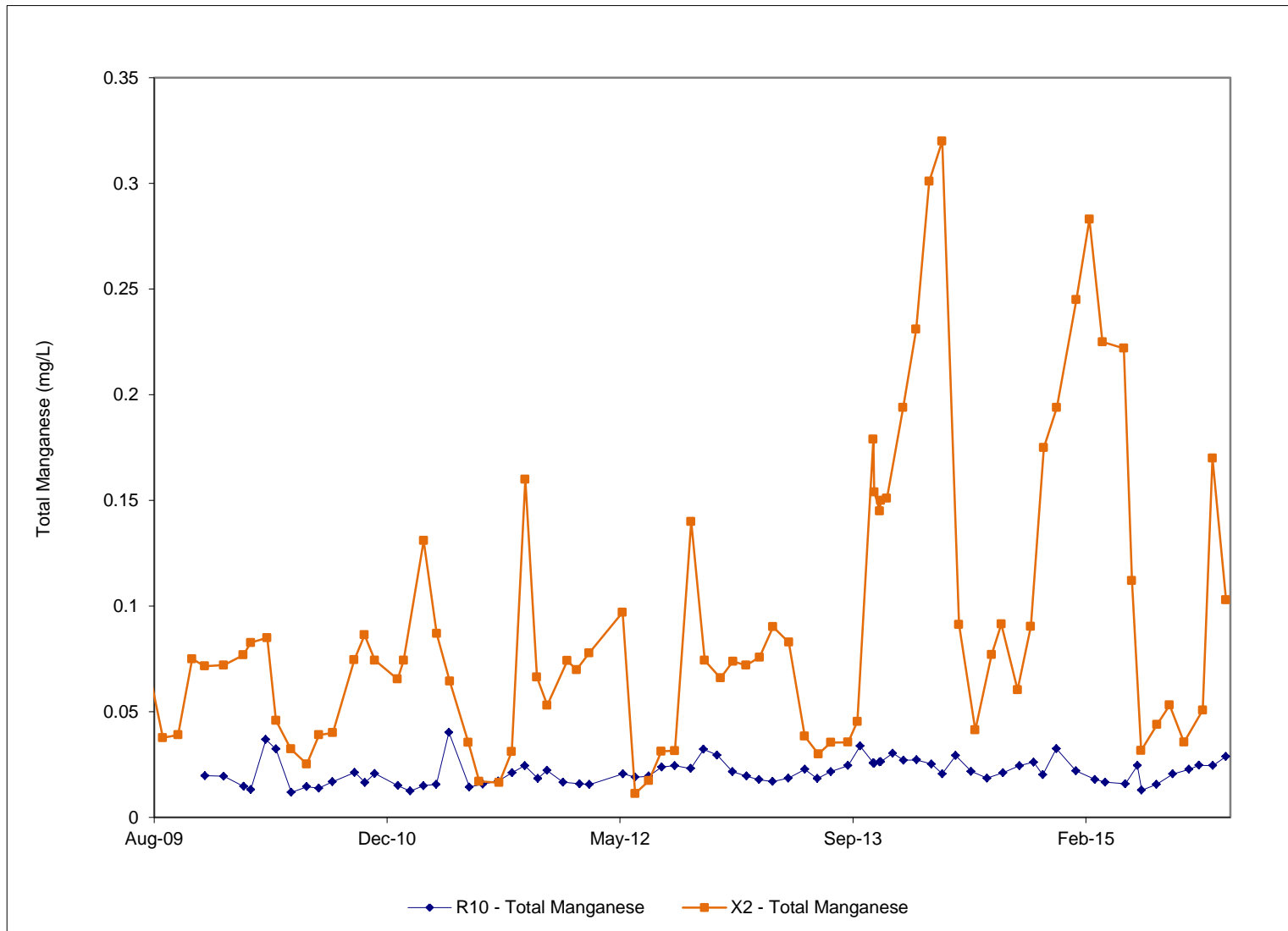
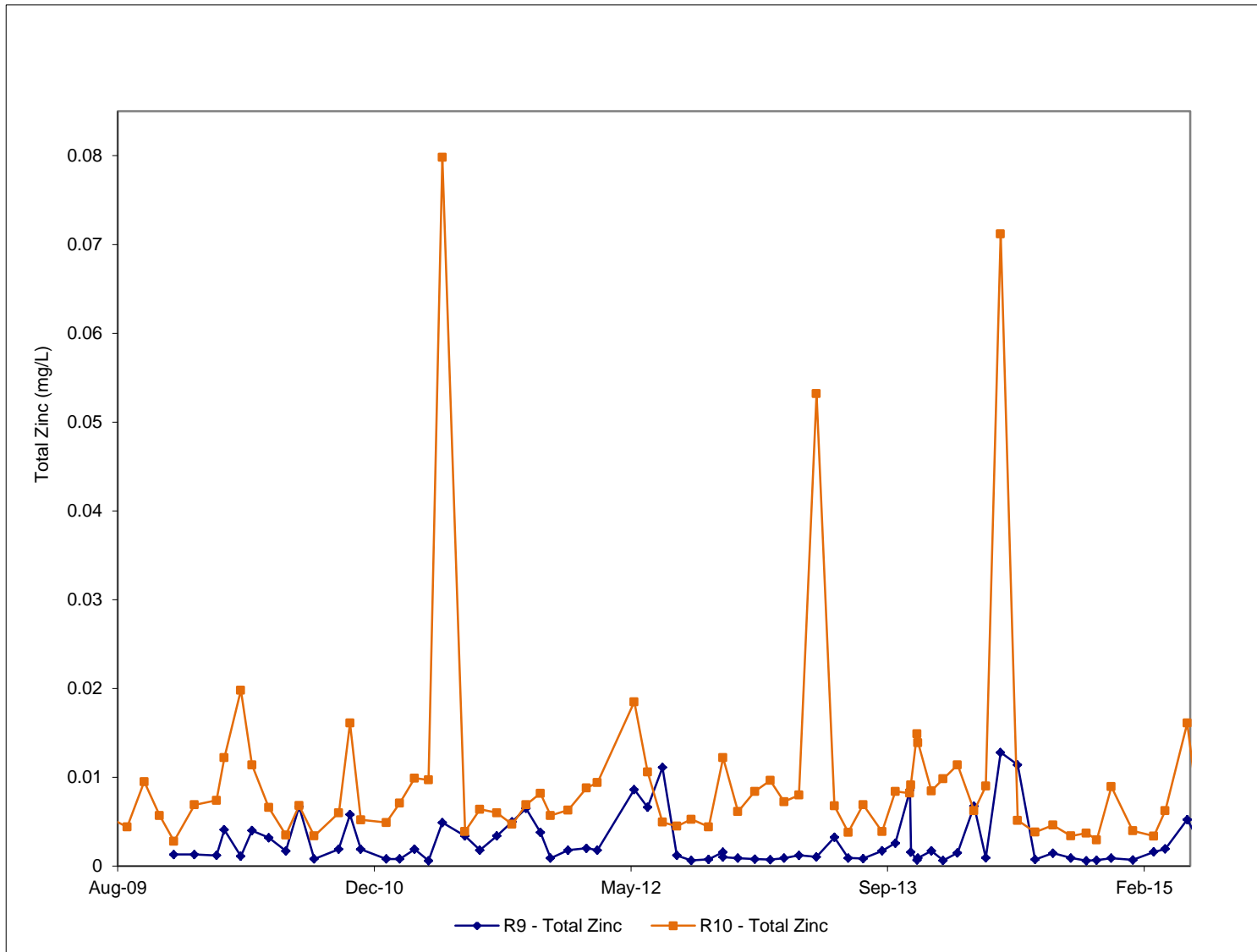


Figure 25: Total Zinc Concentrations Measured at R9 and R10 (2009 to 2015)





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