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Chemical Composition Analysis and Product Consistency Tests to Support Enhanced Hanford Waste Glass Models: Results for the Third Set of High Alumina Outer Layer Matrix Glasses

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EXECUTIVE SUMMARY

In this report, the Savannah River National Laboratory provides chemical analyses and Product Consistency Test (PCT) results for 14 simulated high level waste glasses fabricated by the Pacific Northwest National Laboratory. The results of these analyses will be used as part of efforts to revise or extend the validation regions of the current Hanford Waste Treatment and Immobilization Plant glass property models to cover a broader span of waste compositions.

The measured chemical composition data are reported and compared with the targeted values for each component for each glass. All of the measured sums of oxides for the study glasses fell within the interval of 96.9 to 100.8 wt %, indicating recovery of all components. Comparisons of the targeted and measured chemical compositions showed that the measured values for the glasses met the targeted concentrations within 10% for those components present at more than 5 wt %.

The PCT results were normalized to both the targeted and measured compositions of the study glasses. Several of the glasses exhibited increases in normalized concentrations (NC_i) after the canister centerline cooled (CCC) heat treatment. Five of the glasses, after the CCC heat treatment, had NC_B values that exceeded that of the Environmental Assessment (EA) benchmark glass. These results can be combined with additional characterization, including X-ray diffraction, to determine the cause of the higher release rates.

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LIST OF ABBREVIATIONS

AD	Acid Dissolution
AR	As Received
ARM	Approved Reference Material
BDL	Below Detection Limit
CCC	Canister Centerline Cooled
DOE	U.S. Department of Energy
EA	Environmental Assessment benchmark glass
HLW	High Level Waste
ICP-OES	Inductively Coupled Plasma – Optical Emission Spectroscopy
JHCM	Joule-Heated Ceramic Melter
LAW	Low Activity Waste
LRM	Low-level Reference Material
NC_i	Normalized Concentration of element "*i*"
ORP	U.S. Department of Energy – Office of River Protection
PCT	Product Consistency Test
PF	Peroxide Fusion
PNNL	Pacific Northwest National Laboratory
RSD	Relative Standard Deviation
SRNL	Savannah River National Laboratory
TTQAP	Task Technical and Quality Assurance Plan
wt %	Weight Percent
WTP	Hanford Waste Treatment and Immobilization Plant

1.0 Introduction

The U.S. Department of Energy (DOE) Office of River Protection (ORP) has requested that the Savannah River National Laboratory (SRNL) provide expert evaluation and experimental work in support of the River Protection Project vitrification technology development. DOE is building a Waste Treatment and Immobilization Plant (WTP) at the Hanford Site in Washington to remediate 55 million gallons of radioactive waste that is temporarily stored in 177 underground tanks. The low-activity waste (LAW) fraction will be partitioned from the high-level waste (HLW). Both the LAW and HLW will then be vitrified in borosilicate glass with Joule-heated ceramic melters (JHCM).

Efforts are being made to increase the loading of Hanford tank wastes in glass while maintaining the ability to meet processing, regulatory compliance, and product quality requirements. DOE-ORP has requested that SRNL support the advancement of glass formulations and process control strategies in key technical areas, as defined in the Task Technical and Quality Assurance Plan (TTQAP).[1] One of these areas is enhanced HLW glass model applicability regions.

The current WTP glass composition-properties models were developed over a limited waste composition region for processing the initial feed.[2] The glass composition region is sufficient for start-up of the WTP with waste loadings at the minimum contract requirement, but does not extend to the glass compositions expected for a large fraction of tank wastes, nor does it cover compositions from high waste loading glasses. The current WTP algorithms may only allow processing of the potential HLW compositions at significantly reduced waste loadings (see the summary of WTP glass properties models by Vienna et al.[3]). To ensure applicability to the overall mission, DOE-ORP has implemented a program to expand the composition regions of the models.[4-6] New data will be generated in the glass regions of interest. Near term efforts for this task are focused on providing chemical composition analyses and chemical durability evaluations of HLW glasses formulated in new compositional regions of interest to support the expansion of the glass properties models.

In this report, SRNL provides chemical analyses and Product Consistency Test (PCT) results for select simulated HLW glasses fabricated by Pacific Northwest National Laboratory (PNNL).[4,7] The results of these analyses will be used to revise or extend the validation regions of the current WTP glass property models and to develop new models to cover a broader span of waste compositions.

2.0 Experimental Procedure

2.1 Glasses Selected for Study

PNNL provided 14 glasses for this third set of analyses and the identifiers for these glasses are given in Table 2-1. For some of the study glasses, two versions were provided: rapidly cooled (quenched) versions, and Canister Centerline Cooled (CCC) versions, which were heat treated by PNNL to simulate slow cooling at the center of a WTP canister. The quenched glasses were used for chemical analyses. Both the quenched and the CCC glasses, as available, were used for the PCTs. In some cases, results for other versions of these study glasses have been included in previous reports.[8,9]

Table 2-1. Identifiers for PNNL Glasses Characterized in this Study

Glass Identifier
EWG-OL-1755-Mod-8Fe-10B
EWG-OL-3063-Mod-1Zr-3Li
EWG-OL-4744-Mod-7.5Fe-1Zr
EWG-OL-5385-Mod-12B-17Na
EWG-OL-6257-Mod-12B-8Ca
EWG-OL-6311-Mod-Reduced-Na-K
EWG-OL-6489-Mod-11B-15Na
EWG-OL-8548-Mod-1Zr
EWG-OL-10278-Mod-15B-1Zr
EWG-OL-11318-Mod-1Zr
EWG-OL-14547-Mod-Reduced-Alkali-1Zr
EWG-OL-15698-Mod-Low-Na
EWG-OL-6080
EWG-OL-8548

In the sections that follow, the methods used for measuring chemical composition and PCT performance are described and statistical reviews of the resulting data are provided. Detailed data from these analyses are included as appendices.

2.2 Compositional Analysis

Chemical analysis was performed under the auspices of an analytical plan[10] on a representative sample from the quenched version of each of the study glasses to allow for comparisons with the targeted compositions. Two preparation techniques, sodium peroxide fusion (PF) and acid dissolution (AD), were used to prepare the glass samples, in duplicate, for analysis. The PF method is described in an SRNL procedure.[11] The AD method used concentrated nitric acid (HNO_3), hydrochloric acid (HCl), hydrofluoric acid (HF), and saturated boric acid (H_3BO_3). For each sample, a mass of 0.15 ± 0.10 grams of finely crushed glass was added to a flat bottom 60 ml polyethylene vial. A stir bar was then placed in the vial. Volumes of 5 ml of HNO_3 and 5 ml of HF were added to the vial which was then placed on a 15 position multi hot/stir plate. The sample and acids were stirred and heated at 90 °C in a fume hood for 2 hours. Volumes of 5 ml of HCl and 40 ml of saturated H_3BO_3 were then added to the vial, followed by stirring and heating at 90 °C for an additional hour. The digested sample was then poured through a funnel into a polyethylene 100 ml volumetric flask. The vial was rinsed with deionized water several times, poured into the volumetric flask, and then deionized water was added to fill the volumetric flask to the 100 ml mark. The final digestion solution was poured into a 125 ml polyethylene bottle for elemental analyses. Limitations of this digestion are that boron concentrations cannot be measured due to the use of boric acid, and silicon concentrations cannot be measured due to HF etching of the quartz torch in the Inductively Coupled Plasma – Optical Emission Spectroscopy (ICP-OES) instrument.

Each of the samples was analyzed, twice for each element of interest, by ICP-OES. A glass standard was also intermittently measured to assess the performance of the ICP-OES instrument over the course of these analyses. Specifically, several samples of the low-level reference material (LRM)[12] were included as part of the analytical plan. In addition, glass EWG-Centroid-2-R1 was included as a matrix standard per request from PNNL.

Two components of the study glasses, fluorine and silver, were not measured since each of these species would have required the use of an additional preparation method. Their targeted concentrations were also low (0.3 wt % F and 0.02 wt % Ag_2O), such that they were likely to be near or below analytical detection limits. After discussion with PNNL, it was determined that the effort needed to measure fluorine and silver was not worthwhile.

The PF method was selected for measurement of the major components of the glasses since SRNL experience has shown it to be an effective method for complete dissolution of simulated HLW glass samples.[8,13,14] Measurement of the minor components using samples prepared with this method is difficult due to the high concentration of salts in the resulting solutions. A 10x dilution is required before analysis of the PF prepared solutions to avoid issues with extinguishing the plasma in the ICP-OES instrument. This dilution results in higher detection limits.

An AD method was used for those components that could not be measured via the PF preparation due to interferences or low (minor) concentrations. Some of the solutions resulting from the AD preparation method contained a small amount of undissolved solids. Previous analyses of the solids remaining in these solutions, from earlier studies of this series of simulated HLW glasses,[8,9] identified crystals with spinel morphology containing Al, Cr, Fe, Mn, and Ni. As a result of these analyses, the samples prepared with the PF method (which did not exhibit undissolved solids) were used in measuring and reporting the concentrations of Cr and Mg, in addition to the other major components of the glasses. The targeted concentrations of these components in the study glasses were high enough that detection limits for the PF prepared solutions were not an issue. The preparation methods used for each of the reported glass components are summarized in Table 2-2.

Table 2-2. Preparation Methods Used in Reporting the Concentrations of Each of the Components of the Study Glasses.

Component	Preparation Method
Ag	Not Analyzed
Al	PF
B	PF
Bi	AD
Ca	PF
Cd	AD
Cr	PF
F	Not Analyzed
Fe	PF
K	AD
Li	PF
Mg	PF
Mn	PF
Na	AD
Ni	PF
P	AD
Pb	AD
Ru	AD
S	AD
Si	PF
Sr	AD
Zr	AD

2.3 Product Consistency Test

The PCT Method-A[15] was performed in triplicate on each of the quenched and CCC versions of the study glasses to assess chemical durability. Also included in the experimental test matrix was the Environmental Assessment (EA) benchmark glass,[16] the Approved Reference Material (ARM) glass,[17] and blanks from the sample cleaning batch. Samples were ground, washed, and prepared according to the standard procedure.[15] Fifteen milliliters of Type-I ASTM water were added to 1.5 g of glass in stainless steel vessels. The vessels were closed, sealed, and placed in an oven at 90 ± 2 °C where the samples were maintained at temperature for 7 days. Once cooled, the resulting solutions were sampled (filtered and acidified), then labeled and analyzed by ICP-OES under the auspices of an analytical plan.[18] Samples of a multi-element, standard solution were also included in the analytical plans as a check on the accuracy of the ICP-OES instrument used for these measurements. Normalized release rates were calculated based on the targeted (provided by PNNL) and measured compositions using the average of the common logarithms of the leachate concentrations.

2.4 Quality Assurance

Requirements for performing reviews of technical reports and the extent of review are established in manual E7 2.60. SRNL documents the extent and type of review using the SRNL Technical Report Design Checklist contained in WSRC-IM-2002-00011, Rev. 2.

3.0 Results and Discussion

3.1 Review and Evaluation of Chemical Composition Measurements

Table A-1 in Appendix A provides the elemental concentration measurements in wt % from the study glasses that were prepared by the AD method. Table A-2 in Appendix A provides the elemental concentration measurements in wt % from these glasses as prepared by the PF method. Elemental measurements for samples of the LRM standard glass are also provided in the tables of Appendix A. These unprocessed data are provided as appendices to this report so that the values are readily available should they be of interest for future reviews.

In the sections that follow, the analytical sequences of the measurements are explored, the measurements of the LRM standard glass are investigated, the measurements for each glass are reviewed, the average chemical composition for each glass is determined, and comparisons are made between the measurements and the targeted compositions for the glasses. JMP Pro (SAS Institute, Inc.)[19] was used to support these analyses.

3.1.1 Treatment of Detection Limits

The elemental concentrations in Table A-1 and Table A-2 were converted to oxide concentrations by multiplying the values for each element by the gravimetric factor for the corresponding oxide. During the process of converting to oxide concentrations, an elemental concentration that was reported to be below the detection limit of the analytical process used was set to the detection limit as the oxide concentration was determined for the purposes of statistical review and calculating a sum of oxides for each glass. Those oxides with measured concentrations that were below the associated detection limit will be denoted with a less than symbol (<) as the measured compositions are reported.

3.1.2 Measurements in Analytical Sequence

Exhibit A-1 in Appendix A provides plots of the wt % measurements generated for prepared samples by oxide and analytical block. The plots are in analytical sequence within each calibration block with different symbols and colors being used to represent each of the study and standard glasses. These plots include all of the measurement data from Table A-1 and Table A-2, with each plotted point identified by its Lab ID. Plotting the data in this format provides an opportunity to identify gross trends in performance of the analytical instrument within and among calibration blocks. A review of these plots identified slight, downward shifts in the measurements of the second sub-blocks for both the first and second block of NiO results. These shifts are on the order of 0.08 wt % and may be the result of a minor difference in instrument calibrations. There do not appear to be any other gross patterns or trends in the analytical process over the course of these measurements.

3.1.3 Composition Measurements by Glass Identifier

Exhibit A-2 in Appendix A provides plots of the oxide concentration measurements by the PNNL Glass ID (including the LRM reference glass) by Lab ID grouped by targeted concentration. Different symbols and colors are used to represent the different glasses. These plots show the individual measurements across the duplicates of each preparation method and the two instrument calibrations for each glass. Plotting the data in this format provides an opportunity to review the values for each individual glass as a function of the duplicate preparations and duplicate measurements. A review of the plots presented in these exhibits reveals the repeatability of the four individual values for each oxide for each glass and leads to the following observations:

- The Al_2O_3 measurements of glasses EWG-OL-6257-Mod-12B-8Ca and EWG-OL-6489-Mod-11B-15Na are low, but are within 10% of the targeted values.
- Measurements of CdO, RuO_2 and SrO were all below detection limits for the study glasses.
- The four measurements for K_2O in glass EWG-OL-6080 are below the targeted value, although the targeted value is less than 5 wt %.
- The four measurements for MnO in glass EWG-OL-1755-Mod-8Fe-10B are below the targeted value, although the targeted value is less than 5 wt %.
- The scatter visible in the NiO measurements reflects the slight downward shifts in the second sub-blocks within each of the two measurement blocks as noted above.
- Measurements of SO_3 in glasses EWG-OL-3063-Mod-1Zr-3Li and EWG-OL-6080 were below detection limits, where the targeted SO_3 concentrations were 0.3 wt %.

None of the observations noted above from Exhibit A-2 indicated an error in preparation or measurement that had to be addressed in treatment of the data. Therefore, the entire set of measurement data was used in determining representative, measured compositions for all of the oxides for the study glasses.

3.1.4 Results for the LRM Standard

Exhibit A-3 in Appendix A provides a review of the LRM results against acceptability limits utilized by SRNL. The review is in the form of plots of the measurements arranged by preparation method and element, framed by upper and lower acceptability limits for the concentration of the element in question. The results show that all of the measurements for the elements present in the LRM standard glass were within the acceptability limits utilized by SRNL in conducting instrument and procedure assessments during the execution of these measurements.

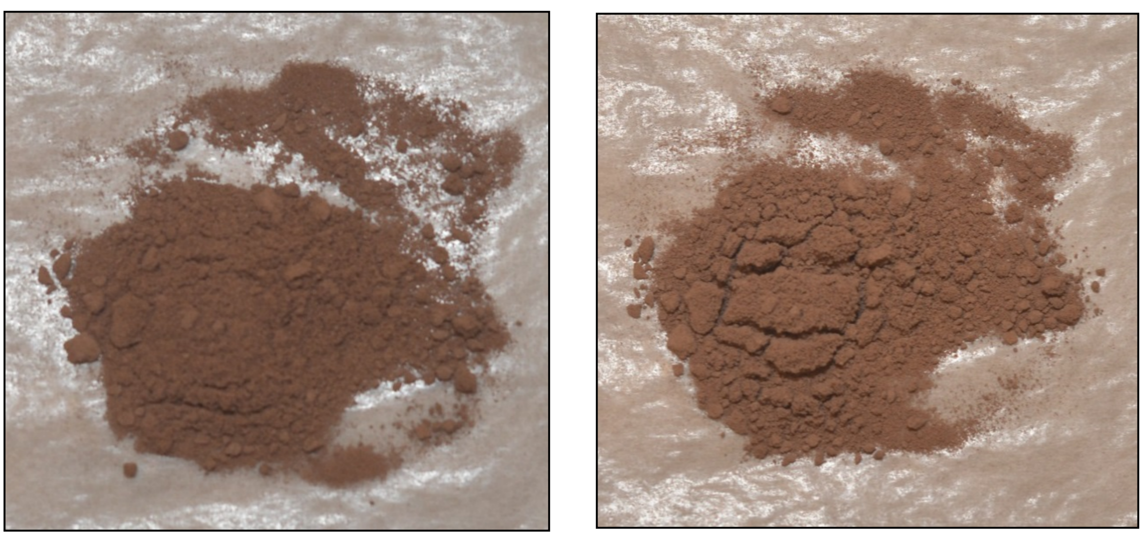
3.1.5 Measured versus Targeted Compositions

From the discussion of Section 3.1.3, all of the measurements for each oxide for each glass (i.e., all of the measurements in Appendix A, Table A-1 and Table A-2), were averaged to determine a representative chemical composition for each glass. A sum of oxides was also computed for each glass based upon the measured values. Exhibit A-4 in Appendix A provides plots showing the result for each glass for each oxide to allow PNNL to draw comparisons between the measured and targeted values.

Table A-3 in Appendix A provides a summary of the average compositions as well as the targeted compositions and some associated differences and relative differences. All of the measured sums of oxides for the study glasses fall within the interval of 96.9 to 100.8 wt %, indicating recovery of all components. Entries in Table A-3 show the relative differences between the measured values and the targeted values for the oxides with targeted values above 5 wt %. The relative differences are typically shaded if they are 10% or more.[a] The measurements of the glasses in this study all exceeded these criteria, thus there are no shaded values found in Table A-3.

3.2 <u>Review and Evaluation of PCT Measurements</u>

One of the study glasses, EWG-OL-4744-Mod-7.5Fe-1Zr-CCC, was difficult to prepare for the PCT. It appeared that the glass was hygroscopic, causing clumping that interfered with grinding and sieving. After discussing with PNNL, it was agreed that this glass would be omitted from the PCT. The ground glass was dried, and then allowed to rest on the lab bench to demonstrate the hygroscopic behavior. A portion of the ground glass was placed in a drying oven at 90 °C overnight. A photo of the dried glass is shown in Figure 3-1. The glass was then placed on the laboratory bench, and its mass was recorded over a period of four hours. The change in mass of the ground glass is given in Table 3-1. A photo of the glass after four hours on the lab bench is shown in Figure 3-1. There was no obvious change in the appearance of the ground glass, but the mass of the powder increased by approximately 8% after exposure to the laboratory atmosphere. Further characterization would be useful to determine the cause of this behavior for this glass composition after the CCC heat treatment.



(a) **(b)**

Figure 3-1. Photos of ground glass EWG-OL-4744-Mod-7.5Fe-1Zr-CCC, before (a) and after (b) drying overnight at 90 °C

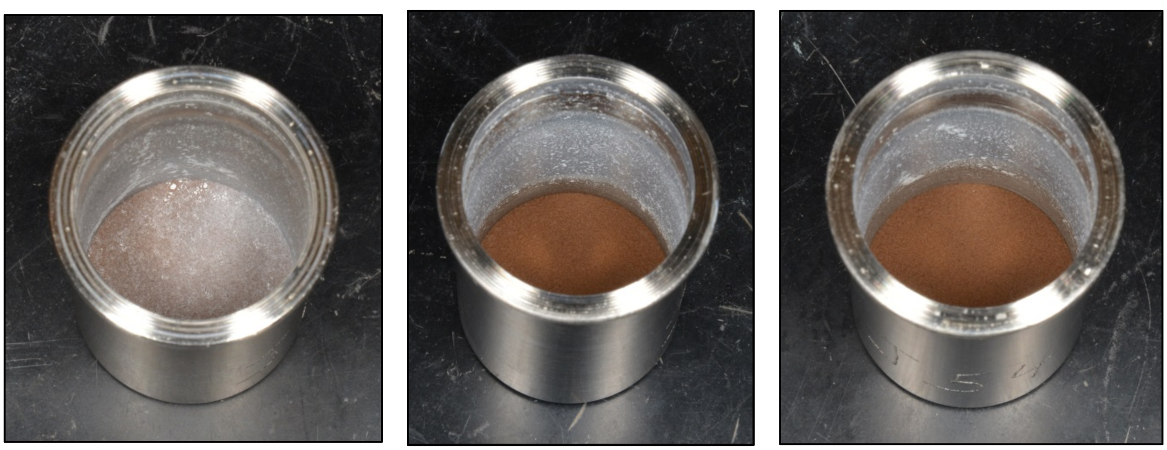
[a] These criteria were selected arbitrarily for the purpose of highlighting differences from targeted concentrations that may be of practical concern.

Table 3-1. Change in mass of ground glass EWG-OL-4744-Mod-7.5Fe-1Zr-CCC over time

Approximate Time Elapsed	Ground Glass Mass (g)
Start, after drying	0.913
5 mins	0.928
20 mins	0.946
2 hrs	0.972
4 hrs	0.983

Another of the study glasses, the CCC version of EWG-OL-6489-Mod-11B-15Na, was observed to "look odd" when the ground and sieved glass was being washed with alcohol, although this was not photographed.

The technician performing the PCT for the study glasses provided some additional observations upon removing the vessels from the oven and filtering the leachates. The three replicates of the quenched version of glass EWG-OL-6489-Mod-11B-15Na left a white residue on the inside of the vessels, as shown in Figure 3-2. The leachates from the CCC version of glass EWG-OL-6311-Mod-Reduced-Na-K were observed to be yellowish in color, as shown in Figure 3-3. It was noted that these leachates were more difficult than usual to pass through a syringe filter. The leachates for the quenched version of glass EWG-OL-8548-Mod-1Zr appeared to have a film on top of them after the vessels were opened, although this was not photographed. These observations will be considered further as the PCT results are reviewed and discussed.



Vessel J52 **Vessel J53** **Vessel J54**

Figure 3-2. Vessels from triplicate PCTs of glass EWG-OL-6489-Mod-11B-15Na-Q showing white residue observed after withdrawing leachate

Figure 3-3. Yellowish leachates resulting from PCT of glass EWG-OL-6311-Mod-Reduced-Na-K-CCC (center and right), with leachate from glass EWG-Centroid-2-R1 shown for comparison (left)

Table B-1 in Appendix B provides the elemental leachate concentration measurements for the solution samples generated by the PCTs for the study glasses and standards. The values for these measurements are given in the table as-received ("ar") from the laboratory analyses and after adjustments for the dilution factors. The measurements for the study glasses, blanks, and the ARM glass were multiplied by 1.6667 to determine the values in parts per million (ppm) and the measurements for EA were multiplied by 16.6667 to determine the values in ppm.

Based on the masses of the PCT vessels before and after the 7-day procedures, there were no samples that had water-loss issues. The ratio of leachant volume to the mass of ground glass was confirmed to be correct for each vessel. The measured concentrations of B, Li, Na, and Si in the leachates from the ARM glasses were compared to the control charts to demonstrate proper performance of the PCTs.[17] Two of the triplicate B values from the first set of PCTs fell outside the limits of the control chart, while all of the measured Li, Na, and Si concentrations in the ARM glass leachates fell within the limits of the control charts. The expectation is that an error in the performance of a PCT would result in a consistent divergence of the concentrations of the analytes of the ARM glass away from the limits of the control charts. Since there were no consistent issues with the ARM values for either of the two sets of PCTs, the tests were considered to have been performed properly and no bias correction was performed.[a] The

[a] Data are provided in Appendix B to support bias correction per ASTM C 1285, Section 25.2 if desired.

measured pH values for each of the PCT leachates are provided in Table B-2 and Table B-3 in Appendix B for reference.

In the sections that follow, the analytical sequences of the measurements are explored, the measurements for each glass are reviewed, the measurements of the multi-element solution standard are investigated, the normalized PCTs for each glass are determined, and comparisons are made between the PCTs for the two heat treatments of each glass. JMP Pro (SAS Institute, Inc.)[19] was used to support these analyses.

3.2.1 Treatment of Detection Limits

Some of the “ar” measurements (Table B-1 in Appendix B) were below the detection limit of 1 ppm (prior to correction for dilution). These measurements (indicated by a “<” symbol in Table B-1) were replaced by their detection limits in subsequent analyses for the purposes of statistical review and calculating normalized leachate values. Those elements with measured concentrations that were below the associated detection limit will be denoted with a less than symbol (<) as the normalized leachate values are reported.

3.2.2 Results for the Samples of the Multi-Element Solution Standard

Table 3-2 provides a review of the measurements of the solution standard samples that were included in the analytical blocks for the PCT analyses. For each analytical block, the mean, standard deviation, and percent relative standard deviation (%RSD) are determined for each element present in the standard. Following the guidance in ASTM C 1285, there were two primary evaluations conducted for these summary statistics: the mean value for each analytical block was found to be less than 10% from the reference value (i.e., a percent relative bias less than 10%) for the element in question, and the %RSD was less than 10% for the element in question. The results in Table 3-2 satisfy these criteria, and thus, the results for the standard suggest no significant issues with the analytical outcomes for the measurements of the PCT solutions.

Table 3-2. Results from Samples of the Multi-Element Solution Standard

Set	1			2			Reference values (mg/L)
Block	1	2	3	1	2	3	
Mean (B (mg/L))	20.13	18.77	19.77	20.23	21.37	20.07	20
Mean (Ca (mg/L))	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	0
Mean (K (mg/L))	10.57	9.88	9.89	9.85	10.73	9.66	10
Mean (Li (mg/L))	10.11	9.76	9.73	9.74	10.26	9.53	10
Mean (Na (mg/L))	82.60	82.47	78.50	78.13	87.77	79.80	81
Mean (P (mg/L))	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	0
Mean (Si (mg/L))	49.40	49.20	47.47	48.30	53.43	48.40	50
% relative bias, B	0.7%	-6.2%	-1.2%	1.2%	6.8%	0.3%	<10% per ASTM C 1285
% relative bias, Ca	n/a	n/a	n/a	n/a	n/a	n/a	
% relative bias, K	5.7%	-1.2%	-1.1%	-1.5%	7.3%	-3.4%	
% relative bias, Li	1.1%	-2.4%	-2.7%	-2.6%	2.6%	-4.7%	
% relative bias, Na	2.0%	1.8%	-3.1%	-3.5%	8.4%	-1.5%	
% relative bias, P	n/a	n/a	n/a	n/a	n/a	n/a	
% relative bias, Si	-1.2%	-1.6%	-5.1%	-3.4%	6.9%	-3.2%	
Std Dev (B (mg/L))	0.321	0.896	0.551	1.290	0.751	0.987	
Std Dev (Ca (mg/L))	0.000	0.000	0.000	0.000	0.000	0.000	
Std Dev (K (mg/L))	0.231	0.012	0.631	0.405	0.503	0.337	
Std Dev (Li (mg/L))	0.156	0.042	0.434	0.312	0.362	0.235	
Std Dev (Na (mg/L))	1.480	0.058	4.423	3.035	4.126	2.433	
Std Dev (P (mg/L))	0.000	0.000	0.000	0.000	0.000	0.000	
Std Dev (Si (mg/L))	0.872	0.346	2.281	1.735	2.312	1.562	
%RSD (B (mg/L))	1.6%	4.8%	2.8%	6.4%	3.5%	4.9%	<10% per ASTM C 1285
%RSD (Ca (mg/L))	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
%RSD (K (mg/L))	2.2%	0.1%	6.4%	4.1%	4.7%	3.5%	
%RSD (Li (mg/L))	1.5%	0.4%	4.5%	3.2%	3.5%	2.5%	
%RSD (Na (mg/L))	1.8%	0.1%	5.6%	3.9%	4.7%	3.0%	
%RSD (P (mg/L))	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
%RSD (Si (mg/L))	1.8%	0.7%	4.8%	3.6%	4.3%	3.2%	

3.2.3 Measurements in Analytical Sequence

Exhibit B-1 in Appendix B provides plots of the common logarithms of the leachate (ppm) concentrations in analytical sequence by analytical block by analytical set. Each of the two analytical sets corresponds to an oven run that was used to conduct the PCT measurements needed to support the study of the HLW Set 3 glasses. Plotting the data in this format provides an opportunity to identify gross trends in performance of the analytical instrument within and among calibration blocks. No issues were observed in these plots.

3.2.4 Measurements by Glass Identifier

Exhibit B-2 in Appendix B provides plots of the leachate concentrations for both the quenched and CCC version of each of the study glasses and for the standards for each analytical set. These plots are in common logarithms of the ppm values and allow for the assessment of the repeatability of the measurements and any differences between the quenched and CCC version of a given glass. For some of the glasses, minor scatter among the triplicate values of some analytes is observed. In addition, there are differences in the PCT responses between the quenched and CCC versions of some of the study glasses. A closer look at the quenched and CCC outcomes is provided in the following sections.

3.2.5 Normalization of the PCT Results

The PCT leachate data were used to determine normalized concentrations for each element of interest using both the targeted and measured compositions of the glasses following the expression given in ASTM C1285:

$$NC_i = \frac{c_i\left(sample\right)}{f_i}$$

where NC_i is the normalized concentration in units of $g_{\text{waste form}}/L_{\text{leachant}}$, c_i is the concentration of element "*i*" in the leachate in units of g_i/L, and f_i is the mass fraction of element "*i*" in the unleached glass in units of g_i/g_{glass}.[a]

An equation was developed to allow for calculation of the NC_i values using the units of measurement provided with the analytical results for this study, and to accommodate the triplicate leachate measurements for each of the study glasses. Note that the symbols in this second equation were kept consistent with those used in ASTM C1285, but the units of measurement have changed. The common logarithm of the normalized concentration for each element "*i*" (NC_i) for each of the study glasses was determined using the equation:

$$\log_{10}\left(NC_i\right) = \overline{\log_{10} c_i} - \left[1 + \log_{10} f_i\right]$$

where NC_i remains in units of $g_{\text{waste form}}/L_{\text{leachant}}$, $\overline{\log_{10} c_i}$ is the average of the common logarithms of the measured concentrations of element "*i*" in the triplicate leachates in units of mg/L, and $\log_{10} f_i$ is either the common logarithm of the targeted concentration of element "*i*" in the glass in units of wt %, or the common logarithm of the average measured concentration of element "*i*" in the glass in units of wt % (from Table A-3 of Appendix A). The calculated NC_i values are discussed further in the following sections.

3.2.6 Effects of Heat Treatments

Exhibit B-3 in Appendix B provides plots of the normalized PCT responses for the two heat treatments (where available) for each of the study glasses as well as the responses for ARM and EA. The results are grouped by compositional view. Note that an indicator is provided as part of these plots to show results involving below detection limit (bdl) values.

The plots of Exhibit B-3 provide a graphical comparison between the PCT responses for the two heat treatments of each study glass. Table 3-3 provides a listing of the normalized PCT responses in g/L. In reading this table, note that bdl values are indicated and that a dash (-) in a cell is used to indicate one of three conditions:

- The ARM glass does not contain K,
- The EA glass does not contain P, and
- PCT results normalized to the targeted and measured compositions are not provided for those components with targeted concentrations of zero for a given glass composition.

A review of the PCT data resulted in several observations:

[a] Note that the waste forms in this study were assumed to be of similar density, the PCT-A reference volume of leachant to sample mass ratio was used, and the 100 to 200 mesh reference particle size was used. Thus, no adjustment for the density of the glasses was made in normalizing the PCT results. Data provided in the appendices of this report allow for the calculation of normalized elemental mass loss (NL_i) if glass densities are measured at a later date.

- The NC_B values for the EA glass samples were lower than the benchmark EA glass value of 16.695 g/L.[16]
- The normalized concentrations for the samples of the EWG-Centroid-2-R1 glass were similar for the two sets of PCTs (e.g., NC_B values in the range of 0.4 to 0.53 g/L), indicating good reproducibility of the PCT results.
- As noted earlier, the CCC version of glass EWG-OL-4744-Mod-7.5Fe-1Zr was omitted from the PCT due to hygroscopic behavior.
- Two of the study glasses, EWG-OL-3063-Mod-1Zr-3Li and EWG-OL-15698-Mod-Low-Na, had NC_B values that were elevated relative to those of the centroid glass, yet below that of the EA glass benchmark. These values were not strongly impacted by heat treatment (relative to some of the other study glasses), although there was some increase in their NC_B values after the CCC heat treatment.
- Two of the study glasses, EWG-OL-6257-Mod-12B-8Ca and EWG-OL-10278-Mod-15B-1Zr, exhibited a stronger impact of heat treatment on the PCT responses, although their NC_B values again remained below that of the EA glass benchmark after the CCC heat treatment.
- Five of the study glasses, after the CCC heat treatment, had NC_B values that exceeded that of the EA glass benchmark: EWG-OL-5385-Mod-12B-17Na, EWG-OL-6311-Mod-Reduced-Na-K, EWG-OL-6489-Mod-11B-15Na, EWG-OL-14547-Mod-Reduced-Alkali-1Zr, and EWG-OL-8548-Mod-1Zr. Four of these glasses exhibited unusual behavior during preparation for the PCT or during handling of the leachates, as described in Section 3.2. Also of note is that for two of these glasses, EWG-OL-6311-Mod-Reduced-Na-K and EWG-OL-6489-Mod-11B-15Na, the NC_P values were lower for the CCC versions than for the quenched versions of the glasses.

It is recommended that a more complete review of the influence of composition and heat treatment on the PCT responses of the glasses described in this report, as well as those described in two previous reports,[8,9] be performed in order to draw further conclusions. Additional characterization, such as X-ray diffraction analysis to identify possible crystalline phases, would be beneficial for further interpretation of the PCT results. One could also examine the glasses for amorphous phase separation using transmission electron microscopy or test for the potential of amorphous phase separation using a model similar to that described by Jantzen, et al.[20]

Table 3-3. Normalized PCT Results

Set	Glass Identifier	Heat Treatment	Comp. View	NC_B (g/L)	NC_{Ca} (g/L)	NC_K (g/L)	NC_{Li} (g/L)	NC_{Na} (g/L)	NC_P (g/L)	NC_{Si} (g/L)
1	ARM-1	ref	ref	0.60	< 0.10	-	0.58	0.50	< 0.59	0.27
1	EA	ref	ref	9.66	< 2.08	< 50.19	5.60	6.83	-	2.39
1	EWG-Centroid-2-R1	quenched	measured	0.53	< 0.07	0.25	0.53	0.37	0.46	0.18
1	EWG-Centroid-2-R1	quenched	targeted	0.52	< 0.07	0.31	0.50	0.37	0.41	0.18
1	EWG-OL-1755-Mod-8Fe-10B	ccc	measured	0.41	-	0.26	0.50	0.28	-	0.32
1	EWG-OL-1755-Mod-8Fe-10B	ccc	targeted	0.41	-	0.27	0.49	0.29	-	0.33
1	EWG-OL-1755-Mod-8Fe-10B	quenched	measured	0.41	-	0.25	0.50	0.25	-	0.31
1	EWG-OL-1755-Mod-8Fe-10B	quenched	targeted	0.42	-	0.26	0.50	0.25	-	0.31
1	EWG-OL-3063-Mod-1Zr-3Li	ccc	measured	14.29	-	0.67	9.82	4.00	0.40	0.23
1	EWG-OL-3063-Mod-1Zr-3Li	ccc	targeted	14.20	-	0.67	9.39	4.12	0.36	0.24
1	EWG-OL-3063-Mod-1Zr-3Li	quenched	measured	13.50	-	0.67	9.06	3.75	0.32	0.22
1	EWG-OL-3063-Mod-1Zr-3Li	quenched	targeted	13.41	-	0.67	8.67	3.87	0.29	0.22
1	EWG-OL-4744-Mod-7.5Fe-1Zr	quenched	measured	5.65	0.04	-	-	6.12	-	0.21
1	EWG-OL-4744-Mod-7.5Fe-1Zr	quenched	targeted	5.72	0.04	-	-	6.25	-	0.21
1	EWG-OL-5385-Mod-12B-17Na	ccc	measured	35.88	0.10	3.34	30.18	27.38	-	0.45
1	EWG-OL-5385-Mod-12B-17Na	ccc	targeted	36.22	0.10	3.39	28.87	27.58	-	0.45
1	EWG-OL-5385-Mod-12B-17Na	quenched	measured	1.92	0.05	1.73	2.38	2.53	-	0.26
1	EWG-OL-5385-Mod-12B-17Na	quenched	targeted	1.93	0.05	1.75	2.28	2.55	-	0.26
1	EWG-OL-6257-Mod-12B-8Ca	ccc	measured	5.27	2.60	0.44	3.51	0.55	-	< 0.01
1	EWG-OL-6257-Mod-12B-8Ca	ccc	targeted	5.15	2.52	0.46	3.29	0.57	-	< 0.01
1	EWG-OL-6257-Mod-12B-8Ca	quenched	measured	0.25	0.07	0.16	0.28	0.21	-	0.08
1	EWG-OL-6257-Mod-12B-8Ca	quenched	targeted	0.25	0.07	0.17	0.26	0.22	-	0.08
1	EWG-OL-6311-Mod-Reduced-Na-K	ccc	measured	77.11	-	-	45.13	29.21	< 0.14	0.52
1	EWG-OL-6311-Mod-Reduced-Na-K	ccc	targeted	78.21	-	-	43.93	29.80	< 0.13	0.53
1	EWG-OL-6311-Mod-Reduced-Na-K	quenched	measured	4.44	-	-	3.54	3.32	3.11	0.61
1	EWG-OL-6311-Mod-Reduced-Na-K	quenched	targeted	4.50	-	-	3.45	3.39	2.75	0.61
1	EWG-OL-6489-Mod-11B-15Na	ccc	measured	49.05	-	3.57	15.41	27.45	0.19	< 0.02
1	EWG-OL-6489-Mod-11B-15Na	ccc	targeted	48.42	-	3.67	14.53	28.31	0.17	< 0.01
1	EWG-OL-6489-Mod-11B-15Na	quenched	measured	8.30	-	3.00	5.41	5.56	3.75	0.03
1	EWG-OL-6489-Mod-11B-15Na	quenched	targeted	8.20	-	3.08	5.10	5.73	3.40	0.03

Table 3-3. Normalized PCT Results (continued)

Set	Glass Identifier	Heat Treatment	Comp. View	NC_B (g/L)	NC_{Ca} (g/L)	NC_K (g/L)	NC_{Li} (g/L)	NC_{Na} (g/L)	NC_P (g/L)	NC_{Si} (g/L)
2	ARM-1	ref	ref	0.54	< 0.10	-	0.57	0.49	< 0.59	0.27
2	EA	ref	ref	11.35	< 2.08	< 50.19	6.46	8.13	-	2.90
2	EWG-Centroid-2-R1	quenched	measured	0.40	< 0.07	0.25	0.51	0.36	< 0.46	0.18
2	EWG-Centroid-2-R1	quenched	targeted	0.40	< 0.07	0.31	0.48	0.37	< 0.41	0.19
2	EWG-OL-10278-Mod-15B-1Zr	ccc	measured	8.75	0.06	4.82	10.28	7.09	-	0.27
2	EWG-OL-10278-Mod-15B-1Zr	ccc	targeted	8.53	0.06	4.97	9.67	7.18	-	0.27
2	EWG-OL-10278-Mod-15B-1Zr	quenched	measured	1.45	0.03	1.17	1.68	1.68	-	0.26
2	EWG-OL-10278-Mod-15B-1Zr	quenched	targeted	1.41	0.03	1.21	1.58	1.70	-	0.26
2	EWG-OL-11318-Mod-1Zr	ccc	measured	3.56	-	-	-	2.56	-	0.23
2	EWG-OL-11318-Mod-1Zr	ccc	targeted	3.49	-	-	-	2.59	-	0.23
2	EWG-OL-11318-Mod-1Zr	quenched	measured	3.66	-	-	-	2.94	-	0.23
2	EWG-OL-11318-Mod-1Zr	quenched	targeted	3.58	-	-	-	2.97	-	0.23
2	EWG-OL-14547-Mod-Reduced-Alkali-1Zr	ccc	measured	37.84	0.08	0.46	51.46	17.18	-	0.85
2	EWG-OL-14547-Mod-Reduced-Alkali-1Zr	ccc	targeted	37.04	0.08	0.47	47.99	17.29	-	0.82
2	EWG-OL-14547-Mod-Reduced-Alkali-1Zr	quenched	measured	2.31	< 0.02	1.80	2.67	2.70	-	0.29
2	EWG-OL-14547-Mod-Reduced-Alkali-1Zr	quenched	targeted	2.26	< 0.02	1.84	2.49	2.72	-	0.28
2	EWG-OL-15698-Mod-Low-Na	ccc	measured	13.65	0.57	-	19.25	9.59	< 0.14	0.08
2	EWG-OL-15698-Mod-Low-Na	ccc	targeted	14.22	0.57	-	18.58	9.81	< 0.13	0.09
2	EWG-OL-15698-Mod-Low-Na	quenched	measured	10.68	< 0.02	-	10.64	8.90	< 0.14	0.41
2	EWG-OL-15698-Mod-Low-Na	quenched	targeted	11.12	< 0.02	-	10.27	9.09	< 0.13	0.42
2	EWG-OL-6080	ccc	measured	0.31	0.08	0.27	-	0.31	< 0.14	0.07
2	EWG-OL-6080	ccc	targeted	0.31	0.08	0.23	-	0.32	< 0.13	0.07
2	EWG-OL-6080	quenched	measured	0.39	0.11	0.34	-	0.37	< 0.14	0.04
2	EWG-OL-6080	quenched	targeted	0.39	0.11	0.29	-	0.39	< 0.13	0.04
2	EWG-OL-8548	quenched	measured	1.04	-	-	-	0.93	0.82	0.31
2	EWG-OL-8548	quenched	targeted	1.06	-	-	-	0.94	0.75	0.31
2	EWG-OL-8548-Mod-1Zr	ccc	measured	90.63	-	-	-	24.58	21.48	0.08
2	EWG-OL-8548-Mod-1Zr	ccc	targeted	91.01	-	-	-	24.71	19.48	0.08
2	EWG-OL-8548-Mod-1Zr	quenched	measured	0.91	-	-	-	0.85	0.74	0.38
2	EWG-OL-8548-Mod-1Zr	quenched	targeted	0.91	-	-	-	0.85	0.67	0.38

4.0 Summary

In this report, SRNL provides chemical analyses and PCT results for 14 simulated HLW glasses fabricated by PNNL. The results of these analyses will be used as part of efforts to revise or extend the validation regions of the current WTP glass property models (or develop new models) to cover a broader span of waste compositions.

The measured chemical composition data are reported and compared with the targeted values for each component for each glass. Two components of the study glasses, fluorine and silver, were not measured since each of these species would have required the use of an additional preparation method and their measured values were likely to be near or below analytical detection limits. All of the measured sums of oxides for the study glasses fell within the interval of 96.9 to 100.8 wt %, indicating recovery of all components. Comparisons of the targeted and measured chemical compositions showed that the measured values for the glasses met the targeted concentrations within 10% for those components present at more than 5 wt %.

The PCT results were normalized to both the targeted and measured compositions of the study glasses. Several observations were made regarding the PCT results. Measurements of the EA benchmark glass were lower than expected, although no issues were found with the performance of the PCTs. The normalized concentrations for the samples of the EWG-Centroid-2-R1 glass were similar for the two sets of PCTs, indicating good reproducibility of the PCT results. Several of the study glasses exhibited heat treatment effects, where normalized concentration values for the CCC versions of the glasses were higher than those of the corresponding quenched versions of the glasses. This may be indicative of crystallization or phase separation. Five of the study glasses, after the CCC heat treatment, had NC_B values that exceeded that of the EA glass benchmark. These results can be combined with additional characterization, including X-ray diffraction, to determine the cause of the higher release rates.

5.0 References

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Appendix A Tables and Exhibits Supporting the Chemical Composition Measurements

Table A-1. AD Measurements of the HLW Study Glasses

ID	Block	Sub Block	Sequence	Lab ID	Bi (wt%)	Cd (wt%)	K (wt%)	Na (wt%)	P (wt%)	Pb (wt%)	Ru (wt%)	S (wt%)	Sr (wt%)	Zr (wt%)
LRM	1	1	1	LRMAD111	<0.100	0.139	1.30	15.8	0.214	<0.100	<0.100	0.087	<0.100	0.696
EWG-OL-8548-Mod-1Zr-Q	1	1	2	V02AD11	<0.100	<0.100	<0.100	13.5	1.20	0.253	<0.100	0.107	<0.100	0.717
EWG-OL-8548-Q	1	1	3	V08AD11	<0.100	<0.100	<0.100	13.6	1.19	0.260	<0.100	0.109	<0.100	2.71
EWG-OL-1755-Mod-8Fe-10B-Q	1	1	4	V09AD11	2.64	<0.100	2.59	3.85	<0.100	0.257	<0.100	0.090	<0.100	0.720
EWG-OL-11318-Mod-1Zr-Q	1	1	5	V03AD21	<0.100	<0.100	<0.100	13.6	<0.100	0.260	<0.100	0.082	<0.100	0.716
EWG-OL-3063-Mod-1Zr-3Li-Q	1	1	6	V12AD11	2.61	<0.100	2.49	3.84	1.19	0.263	<0.100	<0.050	<0.100	0.705
EWG-OL-8548-Mod-1Zr-Q	1	1	7	V02AD21	<0.100	<0.100	<0.100	13.5	1.18	0.251	<0.100	0.108	<0.100	0.711
EWG-OL-6489-Mod-11B-15Na-Q	1	1	8	V04AD11	<0.100	<0.100	2.57	11.5	1.19	0.244	<0.100	0.125	<0.100	<0.100
EWG-OL-10278-Mod-15B-1Zr-Q	1	1	9	V05AD21	<0.100	<0.100	2.58	11.3	<0.100	0.248	<0.100	0.127	<0.100	0.708
LRM	1	1	10	LRMAD112	<0.100	0.136	1.30	15.9	0.211	<0.100	<0.100	0.090	<0.100	0.702
EWG-OL-8548-Q	1	1	11	V08AD21	<0.100	<0.100	<0.100	13.5	1.20	0.259	<0.100	0.111	<0.100	2.74
EWG-OL-11318-Mod-1Zr-Q	1	1	12	V03AD11	<0.100	<0.100	<0.100	13.5	<0.100	0.259	<0.100	0.084	<0.100	0.720
EWG-OL-6257-Mod-12B-8Ca-Q	1	1	13	V06AD21	2.59	<0.100	2.61	3.90	<0.100	0.247	<0.100	0.114	<0.100	<0.100
EWG-OL-6257-Mod-12B-8Ca-Q	1	1	14	V06AD11	2.57	<0.100	2.59	3.87	<0.100	0.247	<0.100	0.112	<0.100	<0.100
EWG-OL-6489-Mod-11B-15Na-Q	1	1	15	V04AD21	<0.100	<0.100	2.58	11.5	1.21	0.248	<0.100	0.130	<0.100	<0.100
EWG-OL-3063-Mod-1Zr-3Li-Q	1	1	16	V12AD21	2.62	<0.100	2.48	3.84	1.21	0.265	<0.100	<0.050	<0.100	0.720
EWG-OL-1755-Mod-8Fe-10B-Q	1	1	17	V09AD21	2.63	<0.100	2.56	3.80	<0.100	0.258	<0.100	0.095	<0.100	0.731
EWG-OL-10278-Mod-15B-1Zr-Q	1	1	18	V05AD11	<0.100	<0.100	2.58	11.3	<0.100	0.245	<0.100	0.132	<0.100	0.718
LRM	1	1	19	LRMAD113	<0.100	0.138	1.31	16.0	0.223	<0.100	<0.100	0.092	<0.100	0.709
LRM	1	2	1	LRMAD121	<0.100	0.135	1.28	15.7	0.219	<0.100	<0.100	0.084	<0.100	0.687
EWG-OL-10278-Mod-15B-1Zr-Q	1	2	2	V05AD22	<0.100	<0.100	2.56	11.3	<0.100	0.244	<0.100	0.126	<0.100	0.695
EWG-OL-11318-Mod-1Zr-Q	1	2	3	V03AD22	<0.100	<0.100	<0.100	13.3	<0.100	0.255	<0.100	0.077	<0.100	0.707
EWG-OL-11318-Mod-1Zr-Q	1	2	4	V03AD12	<0.100	<0.100	<0.100	13.2	<0.100	0.251	<0.100	0.079	<0.100	0.700
EWG-OL-6257-Mod-12B-8Ca-Q	1	2	5	V06AD22	2.60	<0.100	2.61	3.90	<0.100	0.242	<0.100	0.108	<0.100	<0.100
EWG-OL-1755-Mod-8Fe-10B-Q	1	2	6	V09AD22	2.60	<0.100	2.53	3.73	<0.100	0.251	<0.100	0.087	<0.100	0.712
EWG-OL-6257-Mod-12B-8Ca-Q	1	2	7	V06AD12	2.54	<0.100	2.54	3.80	<0.100	0.240	<0.100	0.104	<0.100	<0.100
EWG-OL-8548-Q	1	2	8	V08AD12	<0.100	<0.100	<0.100	13.5	1.18	0.251	<0.100	0.099	<0.100	2.64
EWG-OL-8548-Mod-1Zr-Q	1	2	9	V02AD22	<0.100	<0.100	<0.100	13.5	1.19	0.245	<0.100	0.101	<0.100	0.694
LRM	1	2	10	LRMAD122	<0.100	0.131	1.28	15.7	0.208	<0.100	<0.100	0.086	<0.100	0.680
EWG-OL-8548-Q	1	2	11	V08AD22	<0.100	<0.100	<0.100	13.3	1.18	0.252	<0.100	0.102	<0.100	2.63
EWG-OL-1755-Mod-8Fe-10B-Q	1	2	12	V09AD12	2.62	<0.100	2.55	3.77	<0.100	0.248	<0.100	0.085	<0.100	0.703
EWG-OL-6489-Mod-11B-15Na-Q	1	2	13	V04AD22	<0.100	<0.100	2.53	11.4	1.19	0.241	<0.100	0.118	<0.100	<0.100
EWG-OL-6489-Mod-11B-15Na-Q	1	2	14	V04AD12	<0.100	<0.100	2.56	11.5	1.17	0.237	<0.100	0.118	<0.100	<0.100
EWG-OL-10278-Mod-15B-1Zr-Q	1	2	15	V05AD12	<0.100	<0.100	2.54	11.2	<0.100	0.237	<0.100	0.119	<0.100	0.689
EWG-OL-3063-Mod-1Zr-3Li-Q	1	2	16	V12AD22	2.60	<0.100	2.44	3.77	1.17	0.255	<0.100	<0.050	<0.100	0.693
EWG-OL-8548-Mod-1Zr-Q	1	2	17	V02AD12	<0.100	<0.100	<0.100	13.2	1.18	0.242	<0.100	0.098	<0.100	0.697
EWG-OL-3063-Mod-1Zr-3Li-Q	1	2	18	V12AD12	2.64	<0.100	2.48	3.83	1.16	0.251	<0.100	<0.050	<0.100	0.686
LRM	1	2	19	LRMAD123	<0.100	0.129	1.26	15.4	0.207	<0.100	<0.100	0.084	<0.100	0.678
LRM	2	1	1	LRMAD211	<0.100	0.134	1.27	15.7	0.214	<0.100	<0.100	0.087	<0.100	0.684
EWG-OL-15698-Mod-Low-Na-Q	2	1	2	V11AD11	2.60	<0.100	<0.100	11.3	1.22	0.253	<0.100	0.142	<0.100	<0.100
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	2	1	3	V10AD11	2.59	<0.100	<0.100	13.6	<0.100	0.248	<0.100	0.127	<0.100	0.676
EWG-Centroid-2-R1-Q	2	1	4	V07AD11	0.766	<0.100	0.728	8.57	0.389	0.249	<0.100	0.110	<0.100	0.666

Table A-1. AD Measurements of the HLW Study Glasses (continued)

ID	Block	Sub Block	Sequence	Lab ID	Bi (wt%)	Cd (wt%)	K (wt%)	Na (wt%)	P (wt%)	Pb (wt%)	Ru (wt%)	S (wt%)	Sr (wt%)	Zr (wt%)
EWG-OL-6311-Mod-Reduced-Na-K-Q	2	1	5	V14AD21	2.57	<0.100	<0.100	11.3	1.12	0.236	<0.100	0.128	<0.100	<0.100
EWG-OL-5385-Mod-12B-17Na-Q	2	1	6	V13AD21	<0.100	<0.100	2.53	12.7	<0.100	0.215	<0.100	0.116	<0.100	1.30
EWG-Centroid-2-R1-Q	2	1	7	V07AD21	0.735	<0.100	0.704	8.55	0.366	0.229	<0.100	0.099	<0.100	0.642
EWG-OL-6080-Q	2	1	8	V15AD11	<0.100	<0.100	2.09	3.87	1.11	0.233	<0.100	<0.050	<0.100	<0.100
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	2	1	9	V01AD21	2.59	<0.100	1.27	10.3	<0.100	0.223	<0.100	0.116	<0.100	0.655
LRM	2	1	10	LRMAD212	<0.100	0.145	1.27	15.6	0.212	<0.100	<0.100	0.083	<0.100	0.728
EWG-OL-5385-Mod-12B-17Na-Q	2	1	11	V13AD11	<0.100	<0.100	2.53	12.6	<0.100	0.225	<0.100	0.116	<0.100	1.33
EWG-OL-6311-Mod-Reduced-Na-K-Q	2	1	12	V14AD11	2.58	<0.100	<0.100	11.3	1.12	0.235	<0.100	0.128	<0.100	<0.100
EWG-OL-15698-Mod-Low-Na-Q	2	1	13	V11AD21	2.62	<0.100	<0.100	11.2	1.16	0.241	<0.100	0.132	<0.100	<0.100
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	2	1	14	V10AD21	2.60	<0.100	<0.100	13.5	<0.100	0.234	<0.100	0.119	<0.100	0.655
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	2	1	15	V01AD11	2.55	<0.100	1.26	10.1	<0.100	0.231	<0.100	0.117	<0.100	0.666
EWG-OL-6080-Q	2	1	16	V15AD21	<0.100	<0.100	2.10	3.88	1.15	0.245	<0.100	<0.050	<0.100	<0.100
LRM	2	1	17	LRMAD213	<0.100	0.126	1.26	15.5	0.202	<0.100	<0.100	0.081	<0.100	0.665
LRM	2	2	1	LRMAD221	<0.100	0.137	1.28	15.9	0.221	<0.100	<0.100	0.089	<0.100	0.688
EWG-OL-15698-Mod-Low-Na-Q	2	2	2	V11AD12	2.63	<0.100	<0.100	11.6	1.23	0.255	<0.100	0.141	<0.100	<0.100
EWG-OL-6311-Mod-Reduced-Na-K-Q	2	2	3	V14AD12	2.57	<0.100	<0.100	11.5	1.19	0.253	<0.100	0.133	<0.100	<0.100
EWG-Centroid-2-R1-Q	2	2	4	V07AD12	0.779	<0.100	0.730	8.66	0.398	0.254	<0.100	0.110	<0.100	0.675
EWG-OL-5385-Mod-12B-17Na-Q	2	2	5	V13AD22	<0.100	<0.100	2.52	12.8	<0.100	0.247	<0.100	0.125	<0.100	1.40
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	2	2	6	V10AD12	2.58	<0.100	<0.100	13.7	<0.100	0.254	<0.100	0.128	<0.100	0.681
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	2	2	7	V10AD22	2.58	<0.100	<0.100	13.7	<0.100	0.255	<0.100	0.124	<0.100	0.682
EWG-OL-6080-Q	2	2	8	V15AD22	<0.100	<0.100	2.12	3.98	1.23	0.263	<0.100	<0.050	<0.100	<0.100
EWG-Centroid-2-R1-Q	2	2	9	V07AD22	0.780	<0.100	0.725	8.79	0.407	0.259	<0.100	0.111	<0.100	0.682
LRM	2	2	10	LRMAD222	<0.100	0.140	1.28	15.8	0.218	<0.100	<0.100	0.090	<0.100	0.695
EWG-OL-6311-Mod-Reduced-Na-K-Q	2	2	11	V14AD22	2.55	<0.100	<0.100	11.3	1.21	0.259	<0.100	0.139	<0.100	<0.100
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	2	2	12	V01AD12	2.57	<0.100	1.28	10.3	<0.100	0.253	<0.100	0.123	<0.100	0.693
EWG-OL-6080-Q	2	2	13	V15AD12	<0.100	<0.100	2.14	3.95	1.25	0.262	<0.100	<0.050	<0.100	<0.100
EWG-OL-15698-Mod-Low-Na-Q	2	2	14	V11AD22	2.63	<0.100	<0.100	11.4	1.27	0.266	<0.100	0.146	<0.100	<0.100
EWG-OL-5385-Mod-12B-17Na-Q	2	2	15	V13AD12	<0.100	<0.100	2.51	12.7	<0.100	0.250	<0.100	0.124	<0.100	1.39
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	2	2	16	V01AD22	2.53	<0.100	1.28	10.2	<0.100	0.253	<0.100	0.125	<0.100	0.697
LRM	2	2	17	LRMAD223	<0.100	0.144	1.28	15.6	0.222	<0.100	<0.100	0.090	<0.100	0.694

Table A-2. PF Measurements of the HLW Study Glasses

ID	Block	Sub-Blk	Sequence	Lab ID	Al (wt%)	B (wt%)	Ca (wt%)	Cr (wt%)	Fe (wt%)	Li (wt%)	Mg (wt%)	Mn (wt%)	Ni (wt%)	Si (wt%)
LRM	1	1	1	LRMPF111	5.15	2.62	0.564	0.130	1.06	<0.100	<0.100	<0.100	0.140	24.8
EWG-OL-15698-Mod-Low-Na-Q	1	1	2	V11PF11	8.13	3.74	7.35	<0.100	7.10	1.36	2.35	2.44	0.277	10.7
EWG-OL-1755-Mod-8Fe-10B-Q	1	1	3	V09PF11	8.09	3.31	<0.100	0.992	5.83	2.84	<0.100	1.99	0.298	21.0
EWG-Centroid-2-R1-Q	1	1	4	V07PF21	11.6	4.93	2.61	0.516	4.02	1.36	0.198	0.820	0.316	15.2
EWG-OL-5385-Mod-12B-17Na-Q	1	1	5	V13PF21	13.2	3.86	7.13	<0.100	<0.100	1.80	0.490	<0.100	0.313	11.3
EWG-OL-6311-Mod-Reduced-Na-K-Q	1	1	6	V14PF21	8.78	3.84	<0.100	1.09	7.07	2.73	2.43	<0.100	0.311	12.6
EWG-OL-3063-Mod-1Zr-3Li-Q	1	1	7	V12PF11	8.10	7.05	<0.100	1.34	7.46	1.39	<0.100	<0.100	0.321	15.6
EWG-OL-5385-Mod-12B-17Na-Q	1	1	8	V13PF11	13.5	3.96	7.28	<0.100	<0.100	1.85	0.51	<0.100	0.320	11.6
EWG-OL-6311-Mod-Reduced-Na-K-Q	1	1	9	V14PF11	9.02	3.95	<0.100	1.12	7.23	2.80	2.48	<0.100	0.320	12.9
LRM	1	1	10	LRMPF112	5.18	2.55	0.555	0.133	1.07	<0.100	<0.100	<0.100	0.144	25.2
EWG-OL-8548-Q	1	1	11	V08PF11	10.6	2.69	<0.100	1.19	7.29	<0.100	2.38	2.55	0.332	12.9
EWG-OL-1755-Mod-8Fe-10B-Q	1	1	12	V09PF21	7.85	3.24	<0.100	0.979	5.69	2.75	<0.100	1.98	0.292	20.4
EWG-OL-3063-Mod-1Zr-3Li-Q	1	1	13	V12PF21	8.01	7.01	<0.100	1.34	7.38	1.38	<0.100	<0.100	0.320	15.5
EWG-OL-15698-Mod-Low-Na-Q	1	1	14	V11PF21	8.10	3.74	7.24	<0.100	7.07	1.35	2.33	2.48	0.275	10.6
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	1	1	15	V10PF21	10.5	3.47	7.15	1.14	5.38	<0.100	2.28	<0.100	0.315	11.0
EWG-Centroid-2-R1-Q	1	1	16	V07PF11	11.6	4.99	2.58	0.527	4.02	1.36	0.199	0.831	0.322	15.2
EWG-OL-8548-Q	1	1	17	V08PF21	10.6	2.65	<0.100	1.20	7.34	<0.100	2.39	2.55	0.336	12.8
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	1	1	18	V10PF11	10.6	3.48	7.18	1.17	5.52	<0.100	2.34	<0.100	0.329	11.2
LRM	1	1	19	LRMPF113	5.39	2.84	0.571	0.163	1.29	<0.100	<0.100	<0.100	0.181	26.6
LRM	1	2	1	LRMPF121	4.98	2.47	0.471	<0.100	1.05	<0.100	<0.100	<0.100	<0.100	25.5
EWG-OL-1755-Mod-8Fe-10B-Q	1	2	2	V09PF22	7.87	3.13	<0.100	0.882	5.59	2.73	<0.100	1.87	0.208	20.3
EWG-OL-3063-Mod-1Zr-3Li-Q	1	2	3	V12PF12	7.61	6.48	<0.100	1.17	6.96	1.27	<0.100	<0.100	0.225	14.6
EWG-OL-3063-Mod-1Zr-3Li-Q	1	2	4	V12PF22	7.68	6.60	<0.100	1.18	7.00	1.29	<0.100	<0.100	0.223	14.7
EWG-OL-8548-Q	1	2	5	V08PF12	10.2	2.41	<0.100	1.05	6.94	<0.100	2.28	2.32	0.235	12.4
EWG-OL-15698-Mod-Low-Na-Q	1	2	6	V11PF22	7.76	3.42	7.08	<0.100	6.77	1.27	2.23	2.31	0.187	10.3
EWG-Centroid-2-R1-Q	1	2	7	V07PF22	11.2	4.64	2.50	0.426	3.85	1.28	0.132	0.721	0.223	14.7
EWG-OL-5385-Mod-12B-17Na-Q	1	2	8	V13PF12	12.9	3.62	7.00	<0.100	<0.100	1.74	0.431	<0.100	0.233	11.1
EWG-OL-6311-Mod-Reduced-Na-K-Q	1	2	9	V14PF12	8.61	3.62	<0.100	1.00	6.94	2.66	2.39	<0.100	0.230	12.5
LRM	1	2	10	LRMPF122	5.01	2.35	0.478	<0.100	0.988	<0.100	<0.100	<0.100	<0.100	24.8
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	1	2	11	V10PF22	9.82	3.14	6.77	1.00	5.10	<0.100	2.17	<0.100	0.225	10.5
EWG-OL-1755-Mod-8Fe-10B-Q	1	2	12	V09PF12	7.52	2.96	<0.100	0.868	5.48	2.63	<0.100	1.85	0.206	19.8
EWG-OL-8548-Q	1	2	13	V08PF22	10.0	2.35	<0.100	1.06	7.03	<0.100	2.30	2.36	0.246	12.4
EWG-OL-5385-Mod-12B-17Na-Q	1	2	14	V13PF22	12.9	3.61	6.98	<0.100	<0.100	1.72	0.430	<0.100	0.228	11.2
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	1	2	15	V10PF12	9.89	3.13	6.77	1.01	5.15	<0.100	2.19	<0.100	0.228	10.5
EWG-Centroid-2-R1-Q	1	2	16	V07PF12	11.0	4.54	2.38	0.430	3.83	1.26	0.132	0.719	0.230	14.6
EWG-OL-6311-Mod-Reduced-Na-K-Q	1	2	17	V14PF22	8.70	3.71	<0.100	1.02	7.04	2.66	2.41	<0.100	0.235	12.7
EWG-OL-15698-Mod-Low-Na-Q	1	2	18	V11PF12	7.51	3.33	6.76	<0.100	6.66	1.22	2.18	2.27	0.181	10.0
LRM	1	2	19	LRMPF123	4.93	2.31	0.458	<0.100	0.979	<0.100	<0.100	<0.100	<0.100	24.7
LRM	2	1	1	LRMPF211	5.19	2.60	0.592	0.142	1.07	<0.100	<0.100	<0.100	0.135	25.5
EWG-OL-6257-Mod-12B-8Ca-Q	2	1	2	V06PF21	14.7	3.62	5.49	1.04	<0.100	2.59	0.455	<0.100	0.281	13.1
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	2	1	3	V01PF11	8.91	3.75	6.75	1.03	6.72	1.73	<0.100	<0.100	0.282	10.3
EWG-OL-11318-Mod-1Zr-Q	2	1	4	V03PF11	13.2	6.67	0.111	1.09	<0.100	<0.100	1.07	2.44	0.294	11.5

Table A-2. PF Measurements of the HLW Study Glasses (continued)

ID	Block	Sub-Blk	Sequence	Lab ID	Al (wt%)	B (wt%)	Ca (wt%)	Cr (wt%)	Fe (wt%)	Li (wt%)	Mg (wt%)	Mn (wt%)	Ni (wt%)	Si (wt%)
EWG-OL-6257-Mod-12B-8Ca-Q	2	1	5	V06PF11	14.8	3.68	5.49	1.05	<0.100	2.62	0.464	<0.100	0.285	13.2
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	2	1	6	V01PF21	9.01	3.78	6.83	1.03	6.73	1.74	<0.100	<0.100	0.285	10.3
EWG-OL-6489-Mod-11B-15Na-Q	2	1	7	V04PF11	14.7	3.33	<0.100	1.07	<0.100	1.75	2.30	2.35	0.289	10.7
EWG-OL-10278-Mod-15B-1Zr-Q	2	1	8	V05PF21	13.1	4.59	6.97	<0.100	<0.100	2.22	<0.100	1.19	0.294	10.0
EWG-OL-8548-Mod-1Zr-Q	2	1	9	V02PF11	10.8	2.46	<0.100	1.07	6.91	<0.100	2.40	2.41	0.291	13.0
LRM	2	1	10	LRMPF212	4.99	2.38	0.556	0.136	1.03	<0.100	<0.100	<0.100	0.127	24.4
EWG-OL-6080-Q	2	1	11	V15PF11	15.3	6.75	7.14	0.981	<0.100	<0.100	2.28	<0.100	0.297	9.26
EWG-OL-10278-Mod-15B-1Zr-Q	2	1	12	V05PF11	12.9	4.55	6.90	<0.100	<0.100	2.19	<0.100	1.17	0.288	9.87
EWG-OL-8548-Mod-1Zr-Q	2	1	13	V02PF21	10.7	2.46	0.159	1.06	6.87	<0.100	2.38	2.39	0.289	12.9
EWG-OL-11318-Mod-1Zr-Q	2	1	14	V03PF21	13.1	6.73	<0.100	1.08	<0.100	<0.100	1.06	2.41	0.292	11.5
EWG-OL-6080-Q	2	1	15	V15PF21	15.6	6.92	7.30	1.00	<0.100	<0.100	2.32	<0.100	0.308	9.50
EWG-OL-6489-Mod-11B-15Na-Q	2	1	16	V04PF21	14.8	3.38	0.184	1.08	<0.100	1.74	2.29	2.37	0.358	10.7
LRM	2	1	17	LRMPF213	4.89	2.37	0.538	0.135	1.02	<0.100	<0.100	<0.100	0.131	24.3
LRM	2	2	1	LRMPF221	5.14	2.47	0.561	0.104	1.04	<0.100	<0.100	<0.100	0.101	25.5
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	2	2	2	V01PF22	9.08	3.84	6.88	1.00	6.77	1.72	<0.100	<0.100	0.249	10.5
EWG-OL-8548-Mod-1Zr-Q	2	2	3	V02PF12	11.1	2.50	<0.100	1.06	7.03	<0.100	2.43	2.41	0.261	13.3
EWG-OL-6257-Mod-12B-8Ca-Q	2	2	4	V06PF22	15.2	3.67	5.68	1.02	<0.100	2.63	0.446	<0.100	0.254	13.4
EWG-OL-11318-Mod-1Zr-Q	2	2	5	V03PF12	13.1	6.71	<0.100	1.04	<0.100	<0.100	1.04	2.39	0.257	11.5
EWG-OL-10278-Mod-15B-1Zr-Q	2	2	6	V05PF22	12.9	4.48	6.85	<0.100	<0.100	2.16	<0.100	1.12	0.254	9.89
EWG-OL-6257-Mod-12B-8Ca-Q	2	2	7	V06PF12	14.9	3.62	5.54	1.02	<0.100	2.62	0.445	<0.100	0.252	13.3
EWG-OL-6080-Q	2	2	8	V15PF12	15.5	6.70	7.22	0.947	<0.100	<0.100	2.27	<0.100	0.265	9.40
EWG-OL-6489-Mod-11B-15Na-Q	2	2	9	V04PF12	15.3	3.40	<0.100	1.06	<0.100	1.78	2.35	2.39	0.262	11.1
LRM	2	2	10	LRMPF222	5.07	2.41	0.548	0.101	1.02	<0.100	<0.100	<0.100	0.100	25.1
EWG-OL-10278-Mod-15B-1Zr-Q	2	2	11	V05PF12	13.0	4.55	6.91	<0.100	<0.100	2.17	<0.100	1.13	0.254	9.93
EWG-OL-6489-Mod-11B-15Na-Q	2	2	12	V04PF22	15.1	3.38	0.166	1.06	<0.100	1.74	2.31	2.33	0.337	10.9
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	2	2	13	V01PF12	9.11	3.83	6.90	1.01	6.84	1.74	<0.100	<0.100	0.254	10.5
EWG-OL-11318-Mod-1Zr-Q	2	2	14	V03PF22	13.3	6.63	<0.100	1.06	<0.100	<0.100	1.06	2.37	0.262	11.6
EWG-OL-8548-Mod-1Zr-Q	2	2	15	V02PF22	11.3	2.56	0.153	1.07	7.17	<0.100	2.47	2.48	0.269	13.6
EWG-OL-6080-Q	2	2	16	V15PF22	16.0	6.96	7.46	0.985	<0.100	<0.100	2.36	<0.100	0.278	9.72
LRM	2	2	17	LRMPF223	5.14	2.47	0.557	0.106	1.04	<0.100	<0.100	<0.100	0.101	25.4

Table A-3. Comparison of Targeted and Measured Glass Compositions

Glass ID	Oxide	BDL (<)	Measured (wt %)	Targeted (wt %)	Difference of Measured versus Targeted	% Difference of Measured versus Targeted
EWG-Centroid-2-R1-Q	Al_2O_3		21.446	22.000	-0.554	-2.5%
EWG-Centroid-2-R1-Q	B_2O_3		15.375	15.500	-0.125	-0.8%
EWG-Centroid-2-R1-Q	Bi_2O_3		0.853	1.000	-0.147	
EWG-Centroid-2-R1-Q	CaO		3.523	3.500	0.023	
EWG-Centroid-2-R1-Q	CdO	<	0.114	0.100	0.014	
EWG-Centroid-2-R1-Q	Cr_2O_3		0.694	0.750	-0.056	
EWG-Centroid-2-R1-Q	Fe_2O_3		5.619	5.500	0.119	2.2%
EWG-Centroid-2-R1-Q	K_2O		0.869	0.700	0.169	
EWG-Centroid-2-R1-Q	Li_2O		2.831	3.000	-0.169	
EWG-Centroid-2-R1-Q	MgO		0.274	0.500	-0.226	
EWG-Centroid-2-R1-Q	MnO		0.998	1.000	-0.002	
EWG-Centroid-2-R1-Q	Na_2O		11.650	11.500	0.150	1.3%
EWG-Centroid-2-R1-Q	NiO		0.347	0.400	-0.053	
EWG-Centroid-2-R1-Q	P_2O_5		0.894	1.000	-0.106	
EWG-Centroid-2-R1-Q	PbO		0.267	0.300	-0.033	
EWG-Centroid-2-R1-Q	RuO_2	<	0.132	0.010	0.122	
EWG-Centroid-2-R1-Q	SiO_2		31.929	31.500	0.429	1.4%
EWG-Centroid-2-R1-Q	SO_3		0.268	0.300	-0.032	
EWG-Centroid-2-R1-Q	SrO	<	0.118	0.120	-0.002	
EWG-Centroid-2-R1-Q	ZrO_2		0.900	1.000	-0.100	
EWG-Centroid-2-R1-Q	Sum		99.100	99.680	-0.580	-0.6%
EWG-OL-10278-Mod-15B-1Zr-Q	Al_2O_3		24.516	26.000	-1.484	-5.7%
EWG-OL-10278-Mod-15B-1Zr-Q	B_2O_3		14.626	15.000	-0.374	-2.5%
EWG-OL-10278-Mod-15B-1Zr-Q	Bi_2O_3	<	0.112	0.000	0.112	
EWG-OL-10278-Mod-15B-1Zr-Q	CaO		9.665	10.000	-0.335	-3.4%
EWG-OL-10278-Mod-15B-1Zr-Q	CdO	<	0.114	0.100	0.014	
EWG-OL-10278-Mod-15B-1Zr-Q	Cr_2O_3	<	0.146	0.000	0.146	
EWG-OL-10278-Mod-15B-1Zr-Q	Fe_2O_3	<	0.143	0.000	0.143	
EWG-OL-10278-Mod-15B-1Zr-Q	K_2O		3.090	3.000	0.090	
EWG-OL-10278-Mod-15B-1Zr-Q	Li_2O		4.704	5.000	-0.296	-5.9%
EWG-OL-10278-Mod-15B-1Zr-Q	MgO	<	0.166	0.000	0.166	
EWG-OL-10278-Mod-15B-1Zr-Q	MnO		1.488	1.500	-0.012	
EWG-OL-10278-Mod-15B-1Zr-Q	Na_2O		15.199	15.000	0.199	1.3%
EWG-OL-10278-Mod-15B-1Zr-Q	NiO		0.347	0.400	-0.053	
EWG-OL-10278-Mod-15B-1Zr-Q	P_2O_5	<	0.229	0.000	0.229	
EWG-OL-10278-Mod-15B-1Zr-Q	PbO		0.262	0.300	-0.038	
EWG-OL-10278-Mod-15B-1Zr-Q	RuO_2	<	0.132	0.010	0.122	
EWG-OL-10278-Mod-15B-1Zr-Q	SiO_2		21.227	21.960	-0.733	-3.3%
EWG-OL-10278-Mod-15B-1Zr-Q	SO_3		0.315	0.300	0.015	
EWG-OL-10278-Mod-15B-1Zr-Q	SrO	<	0.118	0.120	-0.002	
EWG-OL-10278-Mod-15B-1Zr-Q	ZrO_2		0.949	1.000	-0.051	
EWG-OL-10278-Mod-15B-1Zr-Q	Sum		97.548	99.690	-2.142	-2.1%
EWG-OL-11318-Mod-1Zr-Q	Al_2O_3		24.894	26.000	-1.106	-4.3%
EWG-OL-11318-Mod-1Zr-Q	B_2O_3		21.525	22.000	-0.475	-2.2%
EWG-OL-11318-Mod-1Zr-Q	Bi_2O_3	<	0.112	0.000	0.112	
EWG-OL-11318-Mod-1Zr-Q	CaO	<	0.144	0.000	0.144	
EWG-OL-11318-Mod-1Zr-Q	CdO	<	0.114	0.100	0.014	
EWG-OL-11318-Mod-1Zr-Q	Cr_2O_3		1.560	1.600	-0.040	
EWG-OL-11318-Mod-1Zr-Q	Fe_2O_3	<	0.143	0.000	0.143	
EWG-OL-11318-Mod-1Zr-Q	K_2O	<	0.121	0.000	0.121	
EWG-OL-11318-Mod-1Zr-Q	Li_2O	<	0.215	0.000	0.215	
EWG-OL-11318-Mod-1Zr-Q	MgO		1.754	2.000	-0.246	
EWG-OL-11318-Mod-1Zr-Q	MnO		3.102	3.000	0.102	
EWG-OL-11318-Mod-1Zr-Q	Na_2O		18.063	17.860	0.203	1.1%
EWG-OL-11318-Mod-1Zr-Q	NiO		0.352	0.400	-0.049	
EWG-OL-11318-Mod-1Zr-Q	P_2O_5	<	0.229	0.000	0.229	
EWG-OL-11318-Mod-1Zr-Q	PbO		0.276	0.300	-0.024	

Table A-3. Comparison of Targeted and Measured Glass Compositions (continued)

Glass ID	Oxide	BDL (<)	Measured (wt %)	Targeted (wt %)	Difference of Measured versus Targeted	% Difference of Measured versus Targeted
EWG-OL-11318-Mod-1Zr-Q	RuO_2	<	0.132	0.010	0.122	
EWG-OL-11318-Mod-1Zr-Q	SiO_2		24.655	25.000	-0.345	-1.4%
EWG-OL-11318-Mod-1Zr-Q	SO_3		0.201	0.300	-0.099	
EWG-OL-11318-Mod-1Zr-Q	SrO	<	0.118	0.120	-0.002	
EWG-OL-11318-Mod-1Zr-Q	ZrO_2		0.960	1.000	-0.040	
EWG-OL-11318-Mod-1Zr-Q	Sum		98.670	99.690	-1.020	-1.0%
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	Al_2O_3		17.058	18.150	-1.093	-6.0%
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	B_2O_3		12.236	12.500	-0.264	-2.1%
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	Bi_2O_3		2.854	3.000	-0.146	
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	CaO		9.571	10.000	-0.430	-4.3%
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	CdO	<	0.114	0.100	0.014	
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	Cr_2O_3		1.487	1.600	-0.113	
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	Fe_2O_3		9.672	10.000	-0.328	-3.3%
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	K_2O		1.533	1.500	0.033	
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	Li_2O		3.730	4.000	-0.270	
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	MgO	<	0.166	0.000	0.166	
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	MnO	<	0.129	0.000	0.129	
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	Na_2O		13.783	13.700	0.083	0.6%
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	NiO		0.340	0.400	-0.060	
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	P_2O_5	<	0.229	0.000	0.229	
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	PbO		0.259	0.300	-0.042	
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	RuO_2	<	0.132	0.010	0.122	
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	SiO_2		22.249	23.000	-0.751	-3.3%
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	SO_3		0.300	0.300	0.000	
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	SrO	<	0.118	0.120	-0.002	
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	ZrO_2		0.916	1.000	-0.085	
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	Sum		96.874	99.680	-2.806	-2.8%
EWG-OL-15698-Mod-Low-Na-Q	Al_2O_3		14.880	15.000	-0.120	-0.8%
EWG-OL-15698-Mod-Low-Na-Q	B_2O_3		11.455	11.000	0.455	4.1%
EWG-OL-15698-Mod-Low-Na-Q	Bi_2O_3		2.921	3.000	-0.079	
EWG-OL-15698-Mod-Low-Na-Q	CaO		9.945	10.000	-0.055	-0.6%
EWG-OL-15698-Mod-Low-Na-Q	CdO	<	0.114	0.100	0.014	
EWG-OL-15698-Mod-Low-Na-Q	Cr_2O_3	<	0.146	0.000	0.146	
EWG-OL-15698-Mod-Low-Na-Q	Fe_2O_3		9.865	10.000	-0.135	-1.4%
EWG-OL-15698-Mod-Low-Na-Q	K_2O	<	0.121	0.000	0.121	
EWG-OL-15698-Mod-Low-Na-Q	Li_2O		2.799	2.900	-0.101	
EWG-OL-15698-Mod-Low-Na-Q	MgO		3.769	4.000	-0.232	
EWG-OL-15698-Mod-Low-Na-Q	MnO		3.067	3.000	0.067	
EWG-OL-15698-Mod-Low-Na-Q	Na_2O		15.334	15.000	0.334	2.2%
EWG-OL-15698-Mod-Low-Na-Q	NiO		0.293	0.400	-0.107	
EWG-OL-15698-Mod-Low-Na-Q	P_2O_5		2.796	3.000	-0.205	
EWG-OL-15698-Mod-Low-Na-Q	PbO		0.273	0.300	-0.027	
EWG-OL-15698-Mod-Low-Na-Q	RuO_2	<	0.132	0.010	0.122	
EWG-OL-15698-Mod-Low-Na-Q	SiO_2		22.249	21.550	0.699	3.2%
EWG-OL-15698-Mod-Low-Na-Q	SO_3		0.350	0.300	0.050	
EWG-OL-15698-Mod-Low-Na-Q	SrO	<	0.118	0.120	-0.002	
EWG-OL-15698-Mod-Low-Na-Q	ZrO_2	<	0.135	0.000	0.135	
EWG-OL-15698-Mod-Low-Na-Q	Sum		100.759	99.680	1.079	1.1%
EWG-OL-1755-Mod-8Fe-10B-Q	Al_2O_3		14.800	15.000	-0.201	-1.3%
EWG-OL-1755-Mod-8Fe-10B-Q	B_2O_3		10.175	10.000	0.175	1.7%
EWG-OL-1755-Mod-8Fe-10B-Q	Bi_2O_3		2.924	3.000	-0.076	
EWG-OL-1755-Mod-8Fe-10B-Q	CaO	<	0.140	0.000	0.140	
EWG-OL-1755-Mod-8Fe-10B-Q	CdO	<	0.114	0.100	0.014	
EWG-OL-1755-Mod-8Fe-10B-Q	Cr_2O_3		1.360	1.600	-0.240	
EWG-OL-1755-Mod-8Fe-10B-Q	Fe_2O_3		8.074	8.000	0.074	0.9%
EWG-OL-1755-Mod-8Fe-10B-Q	K_2O		3.081	3.000	0.081	
EWG-OL-1755-Mod-8Fe-10B-Q	Li_2O		5.894	6.000	-0.106	-1.8%
EWG-OL-1755-Mod-8Fe-10B-Q	MgO	<	0.166	0.000	0.166	

Table A-3. Comparison of Targeted and Measured Glass Compositions (continued)

Glass ID	Oxide	BDL (<)	Measured (wt %)	Targeted (wt %)	Difference of Measured versus Targeted	% Difference of Measured versus Targeted
EWG-OL-1755-Mod-8Fe-10B-Q	MnO		2.482	3.000	-0.518	
EWG-OL-1755-Mod-8Fe-10B-Q	Na_2O		5.106	5.000	0.106	2.1%
EWG-OL-1755-Mod-8Fe-10B-Q	NiO		0.319	0.400	-0.081	
EWG-OL-1755-Mod-8Fe-10B-Q	P_2O_5	<	0.229	0.000	0.229	
EWG-OL-1755-Mod-8Fe-10B-Q	PbO		0.273	0.300	-0.027	
EWG-OL-1755-Mod-8Fe-10B-Q	RuO_2	<	0.132	0.010	0.122	
EWG-OL-1755-Mod-8Fe-10B-Q	SiO_2		43.588	42.860	0.728	1.7%
EWG-OL-1755-Mod-8Fe-10B-Q	SO_3		0.223	0.300	-0.077	
EWG-OL-1755-Mod-8Fe-10B-Q	SrO	<	0.118	0.120	-0.002	
EWG-OL-1755-Mod-8Fe-10B-Q	ZrO_2		0.968	1.000	-0.032	
EWG-OL-1755-Mod-8Fe-10B-Q	Sum		100.165	99.690	0.475	0.5%
EWG-OL-3063-Mod-1Zr-3Li-Q	Al_2O_3		14.833	15.000	-0.167	-1.1%
EWG-OL-3063-Mod-1Zr-3Li-Q	B_2O_3		21.847	22.000	-0.153	-0.7%
EWG-OL-3063-Mod-1Zr-3Li-Q	Bi_2O_3		2.918	3.000	-0.082	
EWG-OL-3063-Mod-1Zr-3Li-Q	CaO	<	0.140	0.000	0.140	
EWG-OL-3063-Mod-1Zr-3Li-Q	CdO	<	0.114	0.100	0.014	
EWG-OL-3063-Mod-1Zr-3Li-Q	Cr_2O_3		1.838	1.600	0.238	
EWG-OL-3063-Mod-1Zr-3Li-Q	Fe_2O_3		10.294	10.000	0.294	2.9%
EWG-OL-3063-Mod-1Zr-3Li-Q	K_2O		2.978	3.000	-0.022	
EWG-OL-3063-Mod-1Zr-3Li-Q	Li_2O		2.869	3.000	-0.131	
EWG-OL-3063-Mod-1Zr-3Li-Q	MgO	<	0.166	0.000	0.166	
EWG-OL-3063-Mod-1Zr-3Li-Q	MnO	<	0.129	0.000	0.129	
EWG-OL-3063-Mod-1Zr-3Li-Q	Na_2O		5.149	5.000	0.149	3.0%
EWG-OL-3063-Mod-1Zr-3Li-Q	NiO		0.346	0.400	-0.054	
EWG-OL-3063-Mod-1Zr-3Li-Q	P_2O_5		2.710	3.000	-0.290	
EWG-OL-3063-Mod-1Zr-3Li-Q	PbO		0.279	0.300	-0.022	
EWG-OL-3063-Mod-1Zr-3Li-Q	RuO_2	<	0.132	0.010	0.122	
EWG-OL-3063-Mod-1Zr-3Li-Q	SiO_2		32.303	31.860	0.443	1.4%
EWG-OL-3063-Mod-1Zr-3Li-Q	SO_3	<	0.125	0.300	-0.175	
EWG-OL-3063-Mod-1Zr-3Li-Q	SrO	<	0.118	0.120	-0.002	
EWG-OL-3063-Mod-1Zr-3Li-Q	ZrO_2		0.947	1.000	-0.053	
EWG-OL-3063-Mod-1Zr-3Li-Q	Sum		100.235	99.690	0.544	0.5%
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	Al_2O_3		19.278	19.860	-0.582	-2.9%
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	B_2O_3		10.642	10.500	0.142	1.4%
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	Bi_2O_3		2.885	3.000	-0.116	
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	CaO		9.749	10.000	-0.251	-2.5%
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	CdO	<	0.114	0.100	0.014	
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	Cr_2O_3		1.579	1.600	-0.022	
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	Fe_2O_3		7.560	7.500	0.059	0.8%
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	K_2O	<	0.121	0.000	0.121	
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	Li_2O	<	0.215	0.000	0.215	
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	MgO		3.723	4.000	-0.277	
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	MnO	<	0.129	0.000	0.129	
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	Na_2O		18.367	18.000	0.366	2.0%
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	NiO		0.349	0.400	-0.051	
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	P_2O_5	<	0.229	0.000	0.229	
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	PbO		0.267	0.300	-0.033	
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	RuO_2	<	0.132	0.010	0.122	
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	SiO_2		23.104	23.000	0.104	0.5%
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	SO_3		0.311	0.300	0.011	
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	SrO	<	0.118	0.120	-0.002	
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	ZrO_2		0.910	1.000	-0.090	
EWG-OL-4744-Mod-7.5Fe-1Zr-Q	Sum		99.779	99.690	0.089	0.1%
EWG-OL-5385-Mod-12B-17Na-Q	Al_2O_3		24.800	25.460	-0.660	-2.6%
EWG-OL-5385-Mod-12B-17Na-Q	B_2O_3		12.115	12.000	0.115	1.0%
EWG-OL-5385-Mod-12B-17Na-Q	Bi_2O_3	<	0.112	0.000	0.112	
EWG-OL-5385-Mod-12B-17Na-Q	CaO		9.931	10.000	-0.069	-0.7%
EWG-OL-5385-Mod-12B-17Na-Q	CdO	<	0.114	0.100	0.014	

Table A-3. Comparison of Targeted and Measured Glass Compositions (continued)

Glass ID	Oxide	BDL (<)	Measured (wt %)	Targeted (wt %)	Difference of Measured versus Targeted	% Difference of Measured versus Targeted
EWG-OL-5385-Mod-12B-17Na-Q	Cr_2O_3	<	0.146	0.000	0.146	
EWG-OL-5385-Mod-12B-17Na-Q	Fe_2O_3	<	0.143	0.000	0.143	
EWG-OL-5385-Mod-12B-17Na-Q	K_2O		3.039	3.000	0.039	
EWG-OL-5385-Mod-12B-17Na-Q	Li_2O		3.827	4.000	-0.173	
EWG-OL-5385-Mod-12B-17Na-Q	MgO		0.772	1.000	-0.229	
EWG-OL-5385-Mod-12B-17Na-Q	MnO	<	0.129	0.000	0.129	
EWG-OL-5385-Mod-12B-17Na-Q	Na_2O		17.120	17.000	0.120	0.7%
EWG-OL-5385-Mod-12B-17Na-Q	NiO		0.348	0.400	-0.052	
EWG-OL-5385-Mod-12B-17Na-Q	P_2O_5	<	0.229	0.000	0.229	
EWG-OL-5385-Mod-12B-17Na-Q	PbO		0.252	0.300	-0.048	
EWG-OL-5385-Mod-12B-17Na-Q	RuO_2	<	0.132	0.010	0.122	
EWG-OL-5385-Mod-12B-17Na-Q	SiO_2		24.174	24.000	0.174	0.7%
EWG-OL-5385-Mod-12B-17Na-Q	SO_3		0.300	0.300	0.000	
EWG-OL-5385-Mod-12B-17Na-Q	SrO	<	0.118	0.120	-0.002	
EWG-OL-5385-Mod-12B-17Na-Q	ZrO_2		1.830	2.000	-0.170	
EWG-OL-5385-Mod-12B-17Na-Q	Sum		99.630	99.690	-0.060	-0.1%
EWG-OL-6080-Q	Al_2O_3		29.476	30.000	-0.524	-1.7%
EWG-OL-6080-Q	B_2O_3		22.000	21.860	0.140	0.6%
EWG-OL-6080-Q	Bi_2O_3	<	0.112	0.000	0.112	
EWG-OL-6080-Q	CaO		10.186	10.000	0.186	1.9%
EWG-OL-6080-Q	CdO	<	0.114	0.100	0.014	
EWG-OL-6080-Q	Cr_2O_3		1.430	1.600	-0.170	
EWG-OL-6080-Q	Fe_2O_3	<	0.143	0.000	0.143	
EWG-OL-6080-Q	K_2O		2.545	3.000	-0.455	
EWG-OL-6080-Q	Li_2O	<	0.215	0.000	0.215	
EWG-OL-6080-Q	MgO		3.827	4.000	-0.174	
EWG-OL-6080-Q	MnO	<	0.129	0.000	0.129	
EWG-OL-6080-Q	Na_2O		5.284	5.000	0.284	5.7%
EWG-OL-6080-Q	NiO		0.365	0.400	-0.035	
EWG-OL-6080-Q	P_2O_5		2.715	3.000	-0.285	
EWG-OL-6080-Q	PbO		0.270	0.300	-0.030	
EWG-OL-6080-Q	RuO_2	<	0.132	0.010	0.122	
EWG-OL-6080-Q	SiO_2		20.259	20.000	0.259	1.3%
EWG-OL-6080-Q	SO_3	<	0.125	0.300	-0.175	
EWG-OL-6080-Q	SrO	<	0.118	0.120	-0.002	
EWG-OL-6080-Q	ZrO_2	<	0.135	0.000	0.135	
EWG-OL-6080-Q	Sum		99.580	99.690	-0.110	-0.1%
EWG-OL-6257-Mod-12B-8Ca-Q	Al_2O_3		28.154	30.000	-1.846	-6.2%
EWG-OL-6257-Mod-12B-8Ca-Q	B_2O_3		11.745	12.000	-0.255	-2.1%
EWG-OL-6257-Mod-12B-8Ca-Q	Bi_2O_3		2.871	3.000	-0.129	
EWG-OL-6257-Mod-12B-8Ca-Q	CaO		7.766	8.000	-0.234	-2.9%
EWG-OL-6257-Mod-12B-8Ca-Q	CdO	<	0.114	0.100	0.014	
EWG-OL-6257-Mod-12B-8Ca-Q	Cr_2O_3		1.509	1.600	-0.091	
EWG-OL-6257-Mod-12B-8Ca-Q	Fe_2O_3	<	0.143	0.000	0.143	
EWG-OL-6257-Mod-12B-8Ca-Q	K_2O		3.117	3.000	0.117	
EWG-OL-6257-Mod-12B-8Ca-Q	Li_2O		5.630	6.000	-0.370	-6.2%
EWG-OL-6257-Mod-12B-8Ca-Q	MgO		0.750	1.000	-0.250	
EWG-OL-6257-Mod-12B-8Ca-Q	MnO	<	0.129	0.000	0.129	
EWG-OL-6257-Mod-12B-8Ca-Q	Na_2O		5.213	5.000	0.213	4.3%
EWG-OL-6257-Mod-12B-8Ca-Q	NiO		0.341	0.400	-0.059	
EWG-OL-6257-Mod-12B-8Ca-Q	P_2O_5	<	0.229	0.000	0.229	
EWG-OL-6257-Mod-12B-8Ca-Q	PbO		0.263	0.300	-0.037	
EWG-OL-6257-Mod-12B-8Ca-Q	RuO_2	<	0.132	0.010	0.122	
EWG-OL-6257-Mod-12B-8Ca-Q	SiO_2		28.346	28.860	-0.514	-1.8%
EWG-OL-6257-Mod-12B-8Ca-Q	SO_3		0.273	0.300	-0.027	
EWG-OL-6257-Mod-12B-8Ca-Q	SrO	<	0.118	0.120	-0.0017	
EWG-OL-6257-Mod-12B-8Ca-Q	ZrO_2	<	0.135	0.000	0.1351	
EWG-OL-6257-Mod-12B-8Ca-Q	Sum		96.977	99.690	-2.7126	-2.7%

Table A-3. Comparison of Targeted and Measured Glass Compositions (continued)

Glass ID	Oxide	BDL (<)	Measured (wt %)	Targeted (wt %)	Difference of Measured versus Targeted	% Difference of Measured versus Targeted
EWG-OL-6311-Mod-Reduced-Na-K-Q	Al_2O_3		16.585	17.000	-0.4149	-2.4%
EWG-OL-6311-Mod-Reduced-Na-K-Q	B_2O_3		12.171	12.000	0.1712	1.4%
EWG-OL-6311-Mod-Reduced-Na-K-Q	Bi_2O_3		2.862	3.000	-0.1378	
EWG-OL-6311-Mod-Reduced-Na-K-Q	CaO	<	0.140	0.000	0.1399	
EWG-OL-6311-Mod-Reduced-Na-K-Q	CdO	<	0.114	0.100	0.0142	
EWG-OL-6311-Mod-Reduced-Na-K-Q	Cr_2O_3		1.546	1.600	-0.0544	
EWG-OL-6311-Mod-Reduced-Na-K-Q	Fe_2O_3		10.108	10.000	0.1080	1.1%
EWG-OL-6311-Mod-Reduced-Na-K-Q	K_2O	<	0.121	0.000	0.1205	
EWG-OL-6311-Mod-Reduced-Na-K-Q	Li_2O		5.840	6.000	-0.1603	-2.7%
EWG-OL-6311-Mod-Reduced-Na-K-Q	MgO		4.026	4.000	0.0255	
EWG-OL-6311-Mod-Reduced-Na-K-Q	MnO	<	0.129	0.000	0.1291	
EWG-OL-6311-Mod-Reduced-Na-K-Q	Na_2O		15.300	15.000	0.2998	2.0%
EWG-OL-6311-Mod-Reduced-Na-K-Q	NiO		0.349	0.400	-0.0513	
EWG-OL-6311-Mod-Reduced-Na-K-Q	P_2O_5		2.658	3.000	-0.3420	
EWG-OL-6311-Mod-Reduced-Na-K-Q	PbO		0.265	0.300	-0.0353	
EWG-OL-6311-Mod-Reduced-Na-K-Q	RuO_2	<	0.132	0.010	0.1217	
EWG-OL-6311-Mod-Reduced-Na-K-Q	SiO_2		27.116	26.860	0.2556	1.0%
EWG-OL-6311-Mod-Reduced-Na-K-Q	SO_3		0.330	0.300	0.0296	
EWG-OL-6311-Mod-Reduced-Na-K-Q	SrO	<	0.118	0.120	-0.0017	
EWG-OL-6311-Mod-Reduced-Na-K-Q	ZrO_2	<	0.135	0.000	0.1351	
EWG-OL-6311-Mod-Reduced-Na-K-Q	Sum		100.043	99.690	0.3526	0.4%
EWG-OL-6489-Mod-11B-15Na-Q	Al_2O_3		28.295	30.000	-1.7047	-5.7%
EWG-OL-6489-Mod-11B-15Na-Q	B_2O_3		10.859	11.000	-0.1409	-1.3%
EWG-OL-6489-Mod-11B-15Na-Q	Bi_2O_3	<	0.112	0.000	0.1115	
EWG-OL-6489-Mod-11B-15Na-Q	CaO	<	0.192	0.000	0.1924	
EWG-OL-6489-Mod-11B-15Na-Q	CdO	<	0.114	0.100	0.0142	
EWG-OL-6489-Mod-11B-15Na-Q	Cr_2O_3		1.560	1.600	-0.0397	
EWG-OL-6489-Mod-11B-15Na-Q	Fe_2O_3	<	0.143	0.000	0.1430	
EWG-OL-6489-Mod-11B-15Na-Q	K_2O		3.084	3.000	0.0838	
EWG-OL-6489-Mod-11B-15Na-Q	Li_2O		3.773	4.000	-0.2270	
EWG-OL-6489-Mod-11B-15Na-Q	MgO		3.835	4.000	-0.1652	
EWG-OL-6489-Mod-11B-15Na-Q	MnO		3.047	3.000	0.0472	
EWG-OL-6489-Mod-11B-15Na-Q	Na_2O		15.468	15.000	0.4683	3.1%
EWG-OL-6489-Mod-11B-15Na-Q	NiO		0.396	0.400	-0.0036	
EWG-OL-6489-Mod-11B-15Na-Q	P_2O_5		2.727	3.000	-0.2732	
EWG-OL-6489-Mod-11B-15Na-Q	PbO		0.261	0.300	-0.0388	
EWG-OL-6489-Mod-11B-15Na-Q	RuO_2	<	0.132	0.010	0.1217	
EWG-OL-6489-Mod-11B-15Na-Q	SiO_2		23.211	23.860	-0.6486	-2.7%
EWG-OL-6489-Mod-11B-15Na-Q	SO_3		0.307	0.300	0.0065	
EWG-OL-6489-Mod-11B-15Na-Q	SrO	<	0.118	0.120	-0.0017	
EWG-OL-6489-Mod-11B-15Na-Q	ZrO_2	<	0.135	0.000	0.1351	
EWG-OL-6489-Mod-11B-15Na-Q	Sum		97.770	99.690	-1.9199	-1.9%
EWG-OL-8548-Mod-1Zr-Q	Al_2O_3		20.737	21.500	-0.7627	-3.5%
EWG-OL-8548-Mod-1Zr-Q	B_2O_3		8.034	8.000	0.0337	0.4%
EWG-OL-8548-Mod-1Zr-Q	Bi_2O_3	<	0.112	0.000	0.1115	
EWG-OL-8548-Mod-1Zr-Q	CaO	<	0.179	0.000	0.1791	
EWG-OL-8548-Mod-1Zr-Q	CdO	<	0.114	0.100	0.0142	
EWG-OL-8548-Mod-1Zr-Q	Cr_2O_3		1.557	1.600	-0.0434	
EWG-OL-8548-Mod-1Zr-Q	Fe_2O_3		10.001	10.000	0.0008	0.0%
EWG-OL-8548-Mod-1Zr-Q	K_2O	<	0.121	0.000	0.1205	
EWG-OL-8548-Mod-1Zr-Q	Li_2O	<	0.215	0.000	0.2153	
EWG-OL-8548-Mod-1Zr-Q	MgO		4.013	4.000	0.0131	
EWG-OL-8548-Mod-1Zr-Q	MnO		3.128	3.000	0.1279	
EWG-OL-8548-Mod-1Zr-Q	Na_2O		18.097	18.000	0.0969	0.5%
EWG-OL-8548-Mod-1Zr-Q	NiO		0.353	0.400	-0.0469	
EWG-OL-8548-Mod-1Zr-Q	P_2O_5		2.721	3.000	-0.2790	
EWG-OL-8548-Mod-1Zr-Q	PbO		0.267	0.300	-0.0331	
EWG-OL-8548-Mod-1Zr-Q	RuO_2	<	0.132	0.010	0.1217	

Table A-3. Comparison of Targeted and Measured Glass Compositions (continued)

Glass ID	Oxide	BDL (<)	Measured (wt %)	Targeted (wt %)	Difference of Measured versus Targeted	% Difference of Measured versus Targeted
EWG-OL-8548-Mod-1Zr-Q	SiO_2		28.239	28.360	-0.1212	-0.4%
EWG-OL-8548-Mod-1Zr-Q	SO_3		0.258	0.300	-0.0416	
EWG-OL-8548-Mod-1Zr-Q	SrO	<	0.118	0.120	-0.0017	
EWG-OL-8548-Mod-1Zr-Q	ZrO_2		0.952	1.000	-0.0480	
EWG-OL-8548-Mod-1Zr-Q	Sum		99.347	99.690	-0.3431	-0.3%
EWG-OL-8548-Q	Al_2O_3		19.556	20.000	-0.4437	-2.2%
EWG-OL-8548-Q	B_2O_3		8.130	8.000	0.1302	1.6%
EWG-OL-8548-Q	Bi_2O_3	<	0.112	0.000	0.1115	
EWG-OL-8548-Q	CaO	<	0.140	0.000	0.1399	
EWG-OL-8548-Q	CdO	<	0.114	0.100	0.0142	
EWG-OL-8548-Q	Cr_2O_3		1.644	1.600	0.0443	
EWG-OL-8548-Q	Fe_2O_3		10.222	10.000	0.2224	2.2%
EWG-OL-8548-Q	K_2O	<	0.121	0.000	0.1205	
EWG-OL-8548-Q	Li_2O	<	0.215	0.000	0.2153	
EWG-OL-8548-Q	MgO		3.876	4.000	-0.1237	
EWG-OL-8548-Q	MnO		3.157	3.000	0.1570	
EWG-OL-8548-Q	Na_2O		18.164	18.000	0.1643	0.9%
EWG-OL-8548-Q	NiO		0.366	0.400	-0.0345	
EWG-OL-8548-Q	P_2O_5		2.721	3.000	-0.2790	
EWG-OL-8548-Q	PbO		0.275	0.300	-0.0248	
EWG-OL-8548-Q	RuO_2	<	0.132	0.010	0.1217	
EWG-OL-8548-Q	SiO_2		27.009	26.860	0.1487	0.6%
EWG-OL-8548-Q	SO_3		0.263	0.300	-0.0372	
EWG-OL-8548-Q	SrO	<	0.118	0.120	-0.0017	
EWG-OL-8548-Q	ZrO_2		3.620	4.000	-0.3799	
EWG-OL-8548-Q	Sum		99.956	99.690	0.2655	0.3%
LRM	Al_2O_3		9.614	9.510	0.1044	1.1%
LRM	B_2O_3		8.007	7.850	0.1568	2.0%
LRM	Bi_2O_3	<	0.112	0.000	0.1115	
LRM	CaO		0.752	0.540	0.2120	
LRM	CdO		0.156	0.160	-0.0045	
LRM	Cr_2O_3	<	0.177	0.190	-0.0134	
LRM	Fe_2O_3		1.508	1.380	0.1280	
LRM	K_2O		1.543	1.480	0.0629	
LRM	Li_2O	<	0.215	0.110	0.1053	
LRM	MgO	<	0.166	0.100	0.0658	
LRM	MnO	<	0.129	0.080	0.0491	
LRM	Na_2O		21.186	20.030	1.1561	5.8%
LRM	NiO	<	0.155	0.190	-0.0352	
LRM	P_2O_5		0.491	0.540	-0.0491	
LRM	PbO	<	0.108	0.100	0.0077	
LRM	RuO_2	<	0.132	0.000	0.1317	
LRM	SiO_2		53.803	54.200	-0.3966	-0.7%
LRM	SO_3		0.217	0.300	-0.0830	
LRM	SrO	<	0.118	0.000	0.1183	
LRM	ZrO_2		0.935	0.930	0.0050	
LRM	Sum		99.523	97.690	1.8328	1.9%

Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence

Analyte=Al2O3 (wt%), Prep Method=PF
Variability Chart for Measured

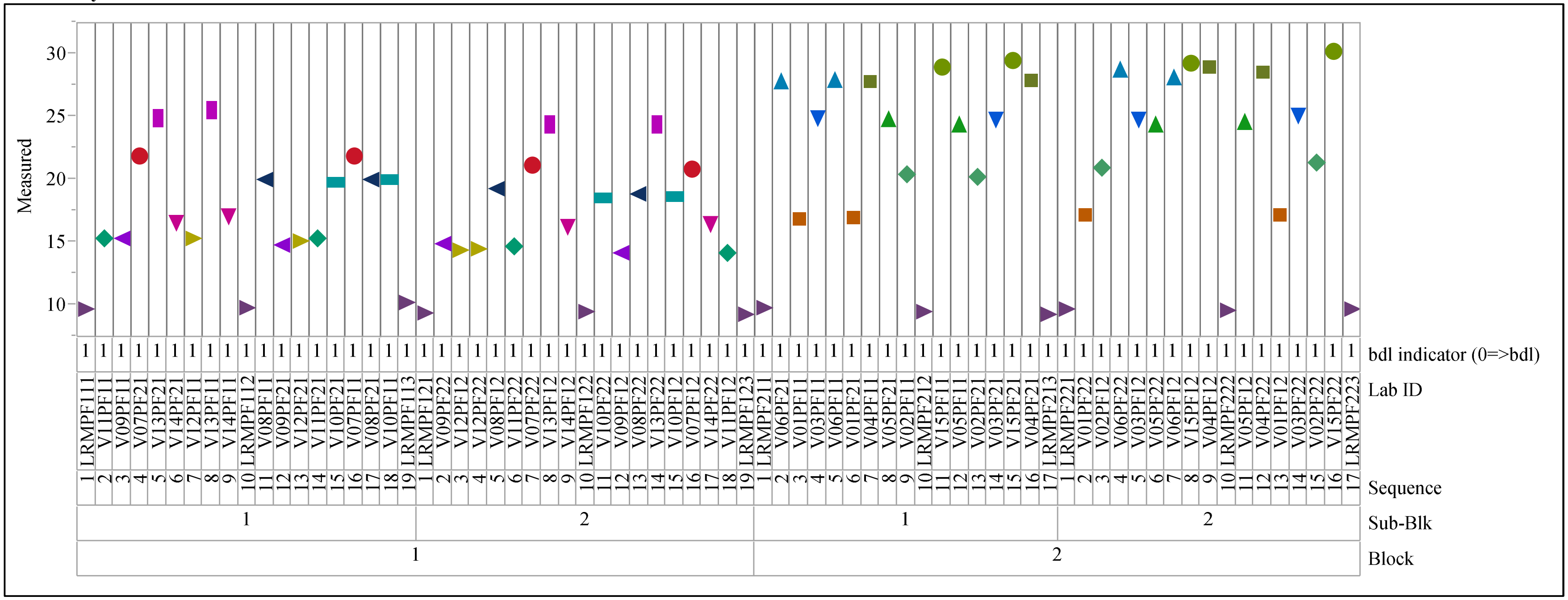


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

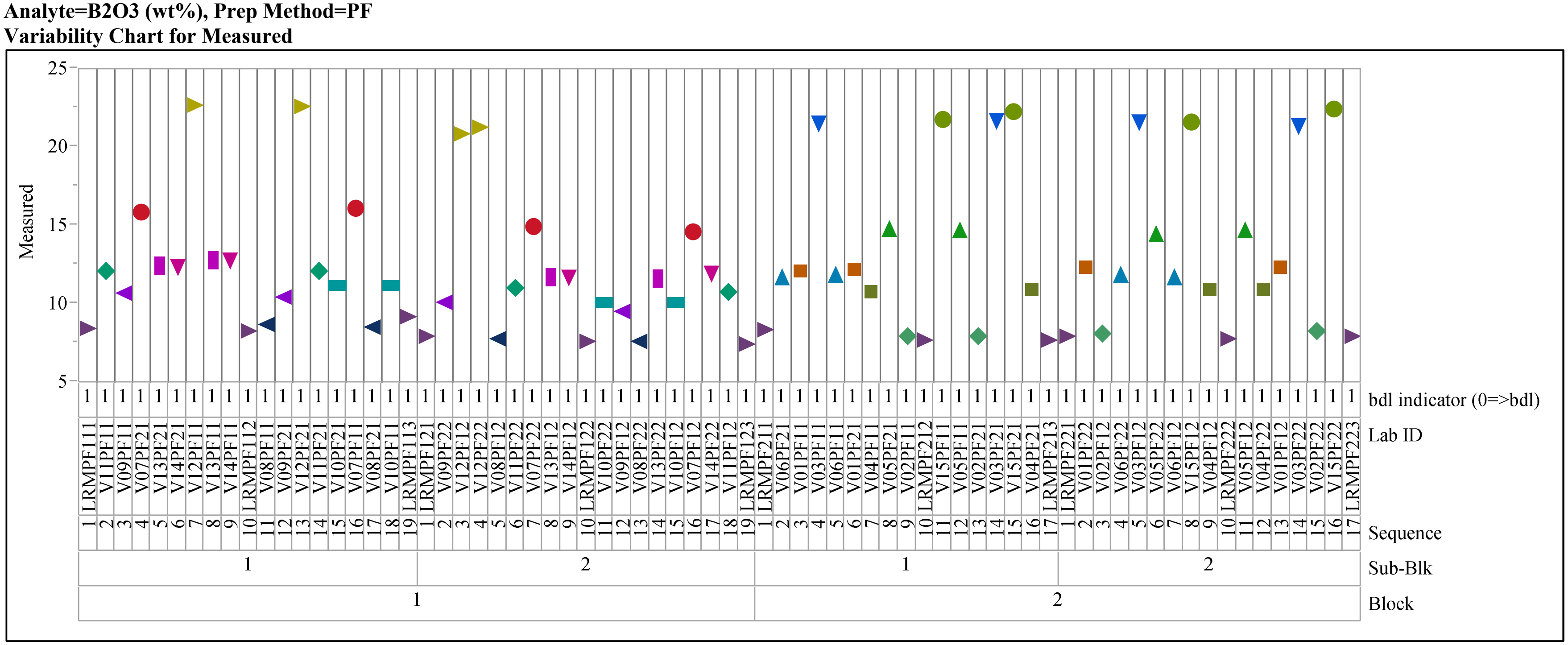


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

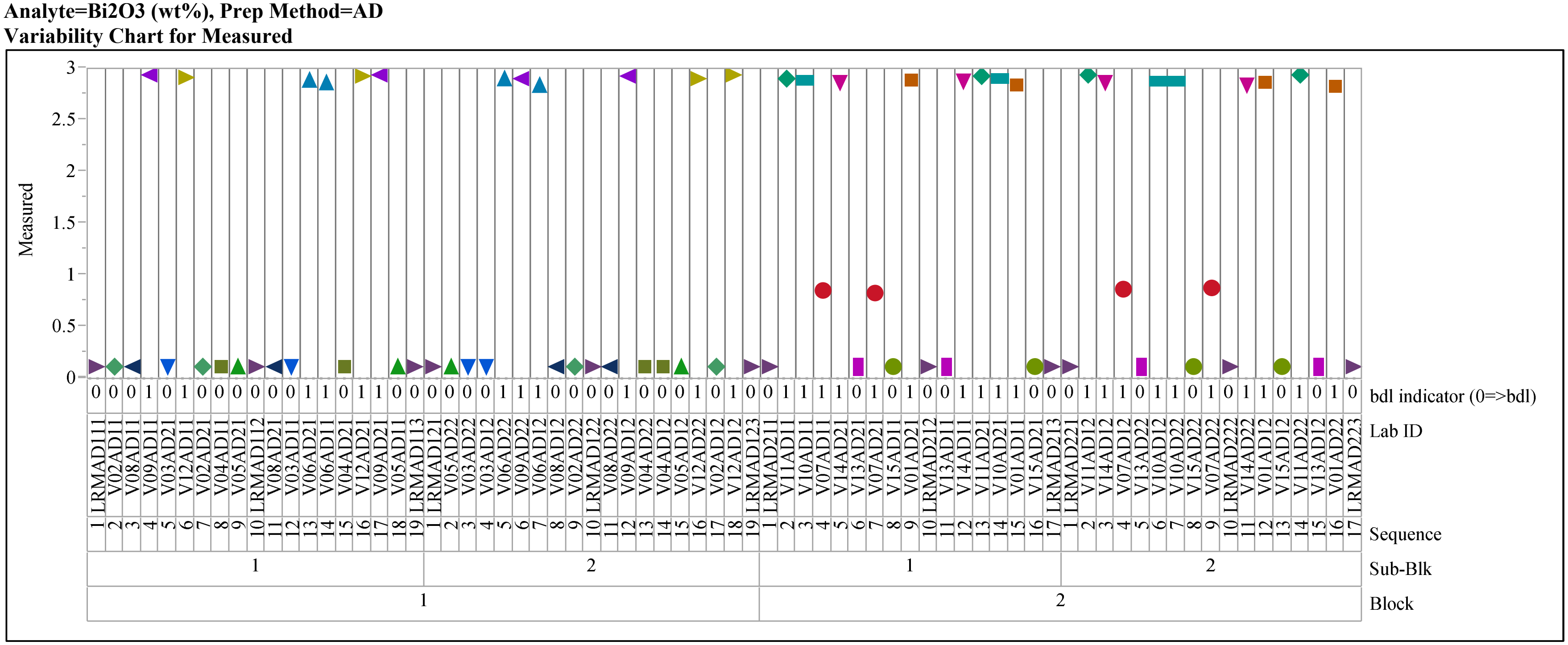


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Analyte=CaO (wt%), Prep Method=PF
Variability Chart for Measured

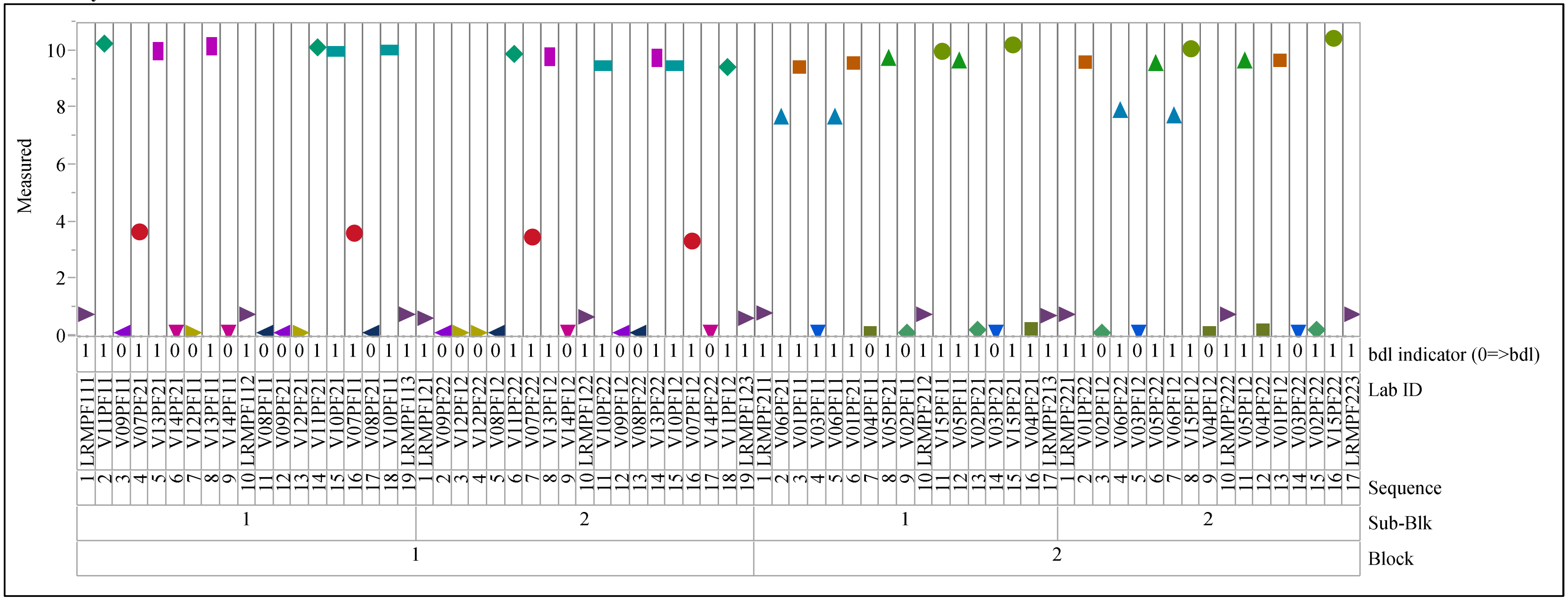


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Analyte=CdO (wt%), Prep Method=AD
Variability Chart for Measured

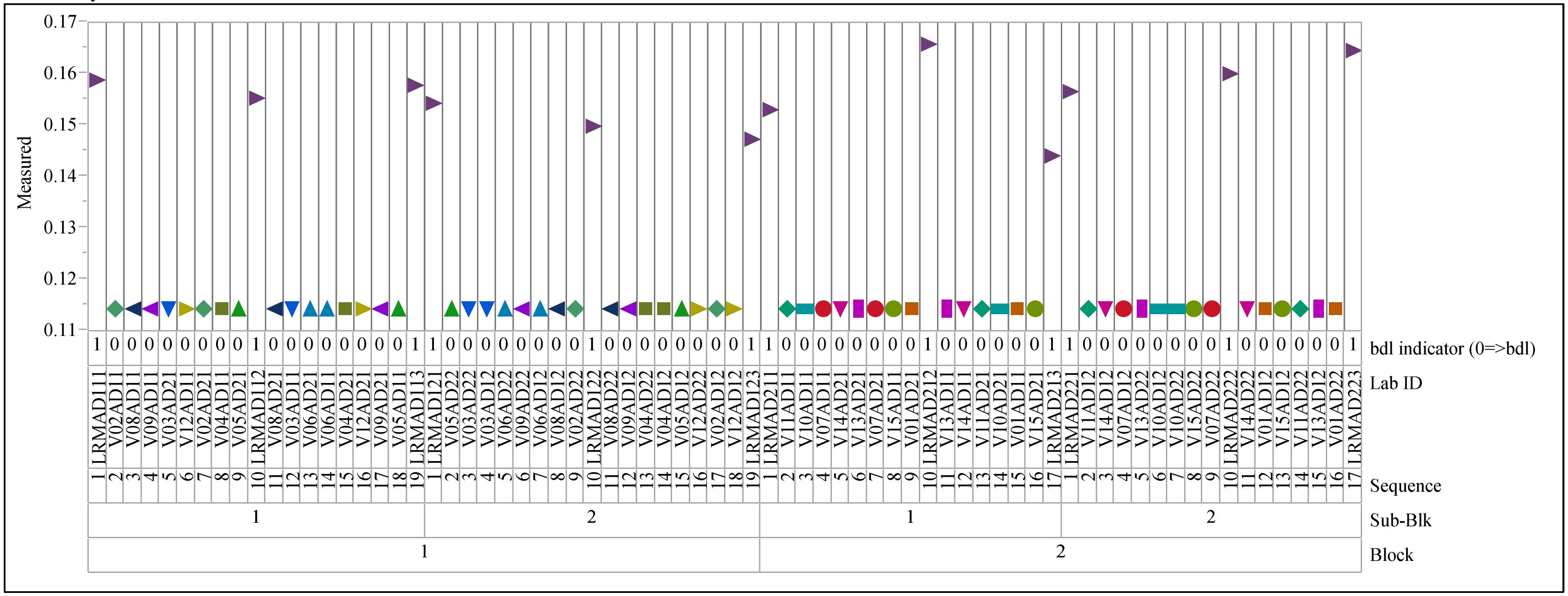


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Analyte=Cr2O3 (wt%), Prep Method=PF
Variability Chart for Measured

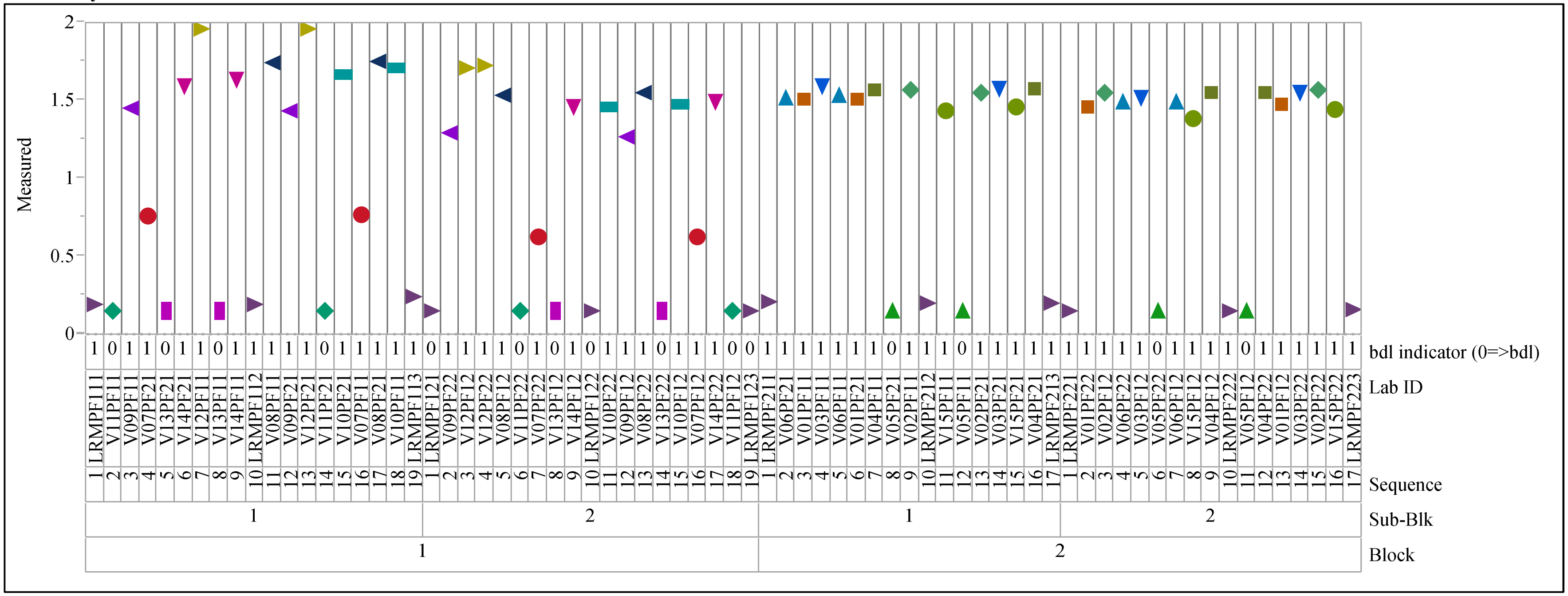


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Analyte=Fe2O3 (wt%), Prep Method=PF
Variability Chart for Measured

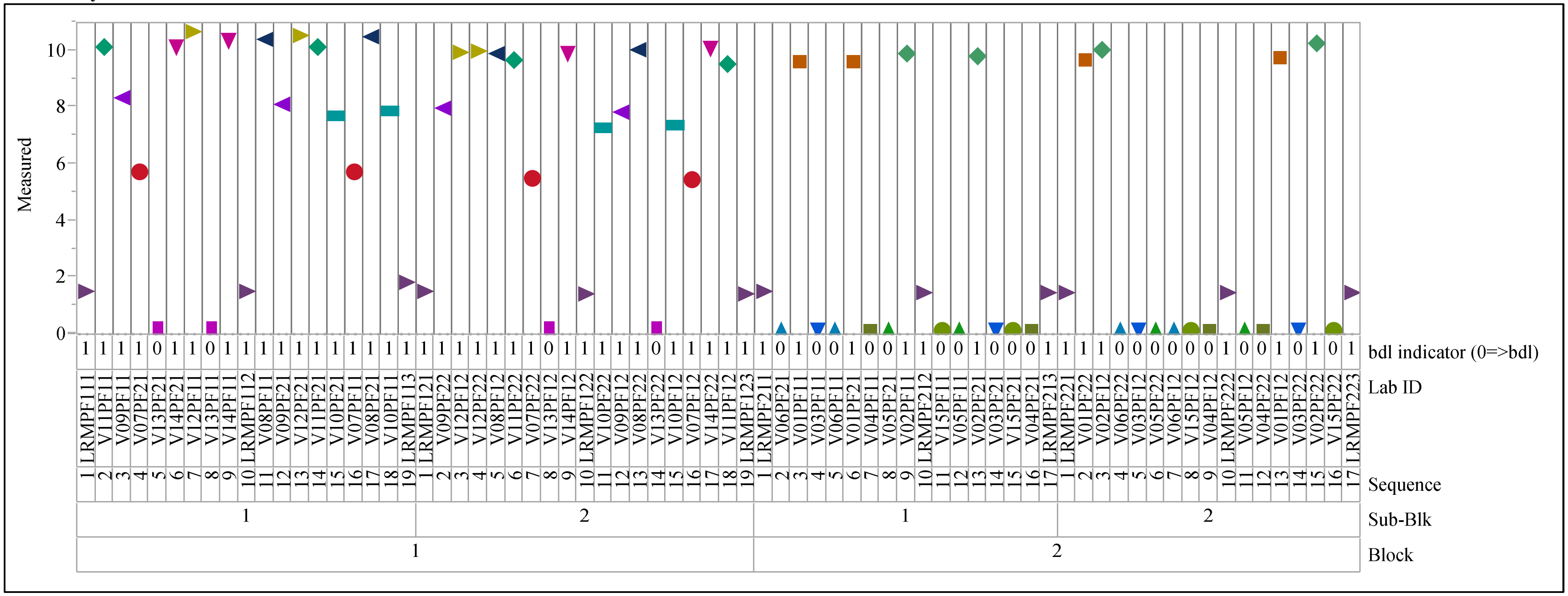


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Analyte=K2O (wt%), Prep Method=AD
Variability Chart for Measured

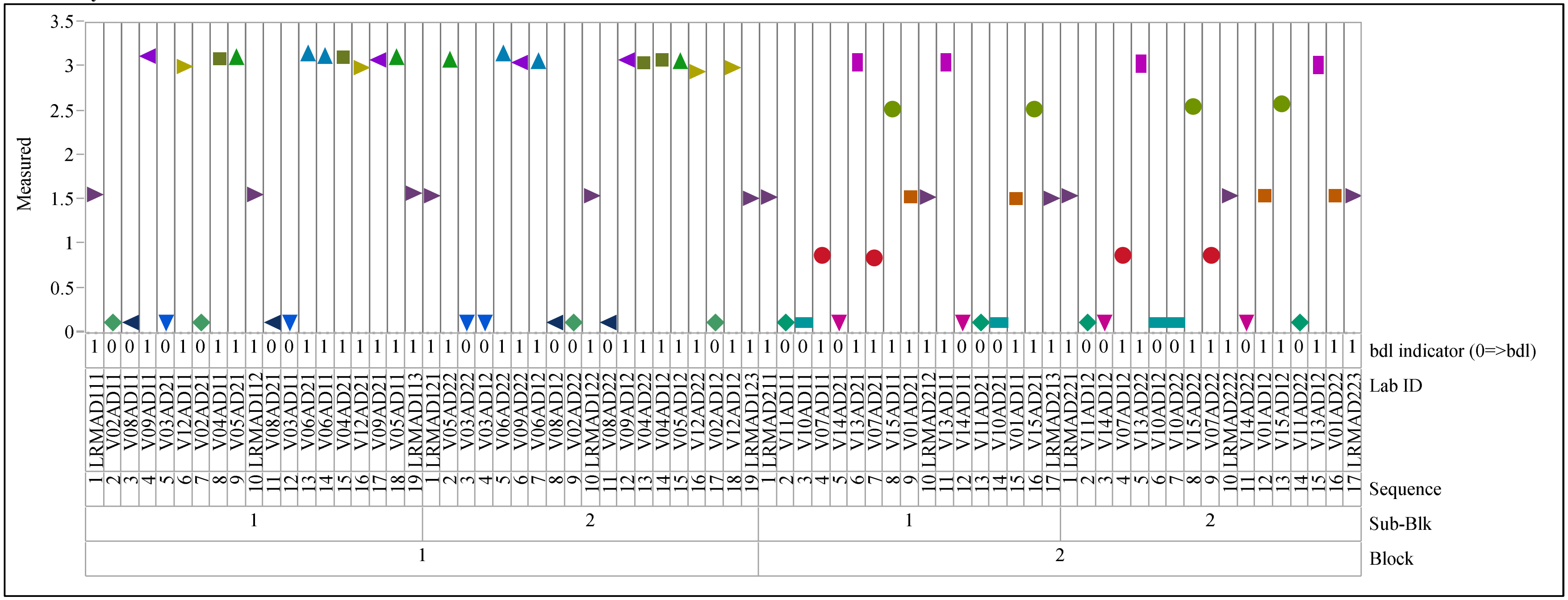


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Analyte=Li2O (wt%), Prep Method=PF
Variability Chart for Measured

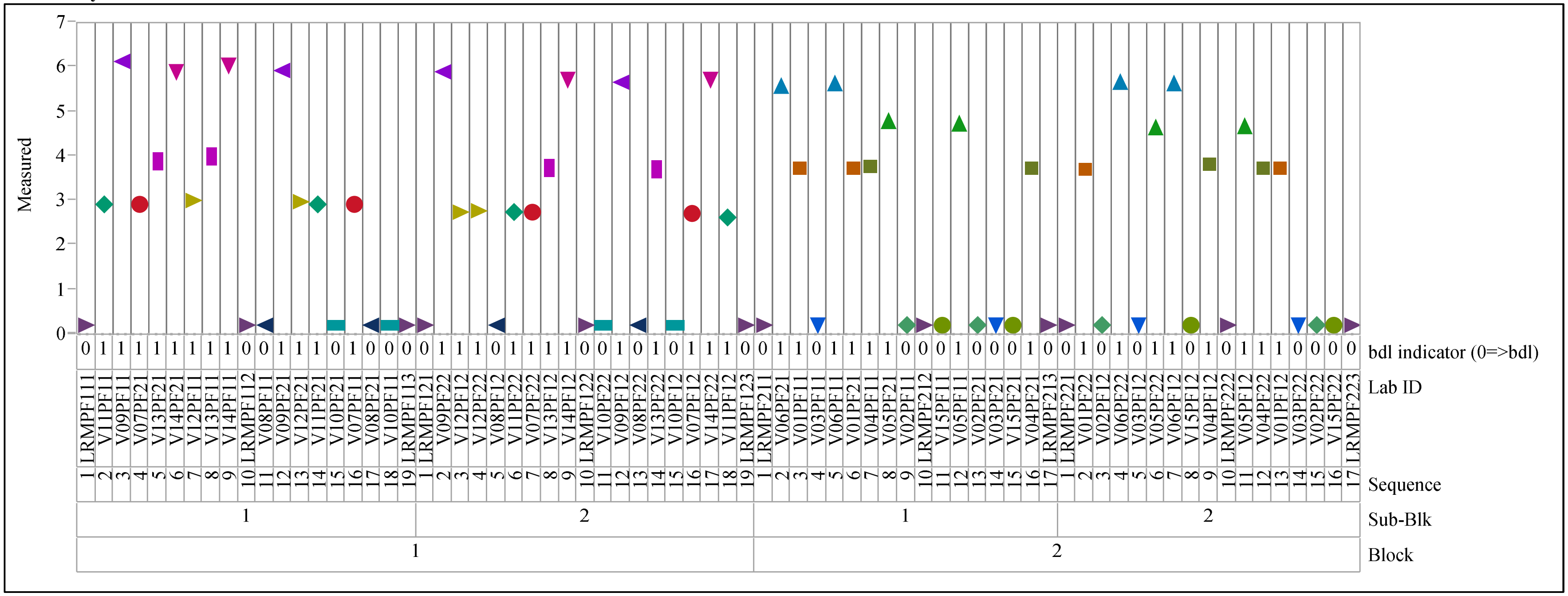


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Analyte=MgO (wt%), Prep Method=PF
Variability Chart for Measured

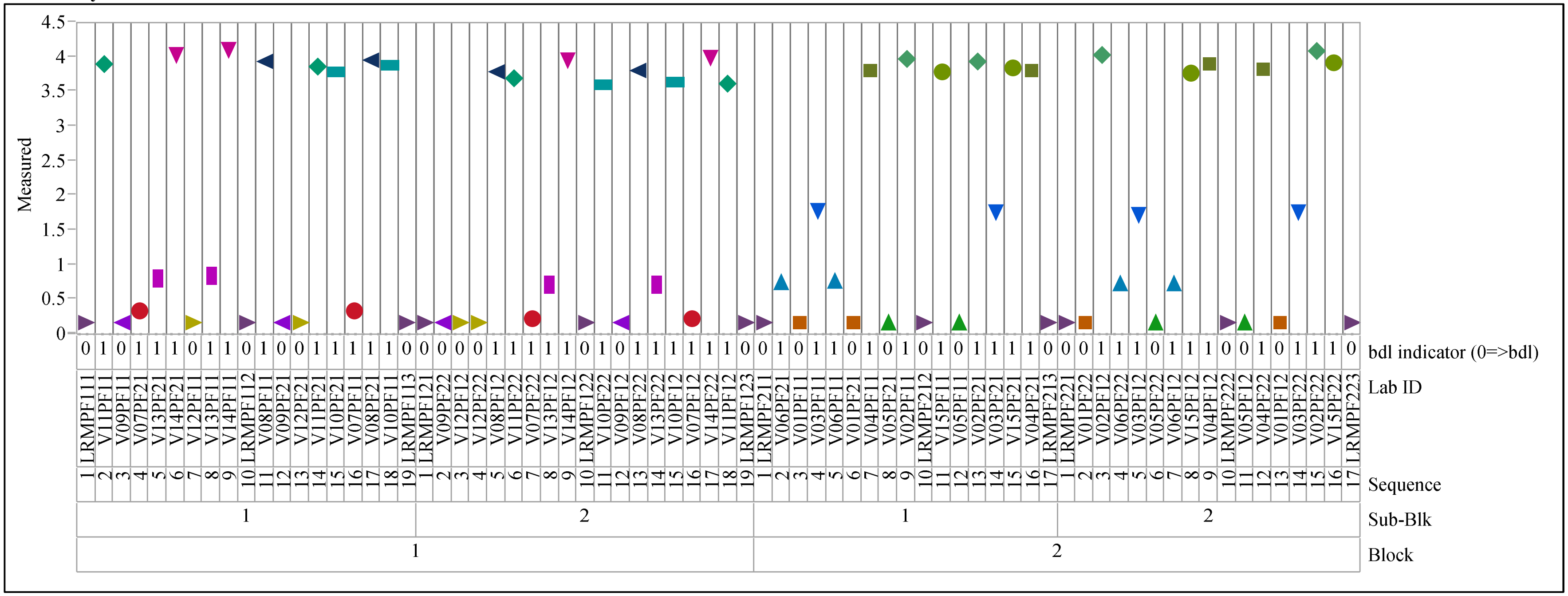


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Analyte=MnO (wt%), Prep Method=PF
Variability Chart for Measured

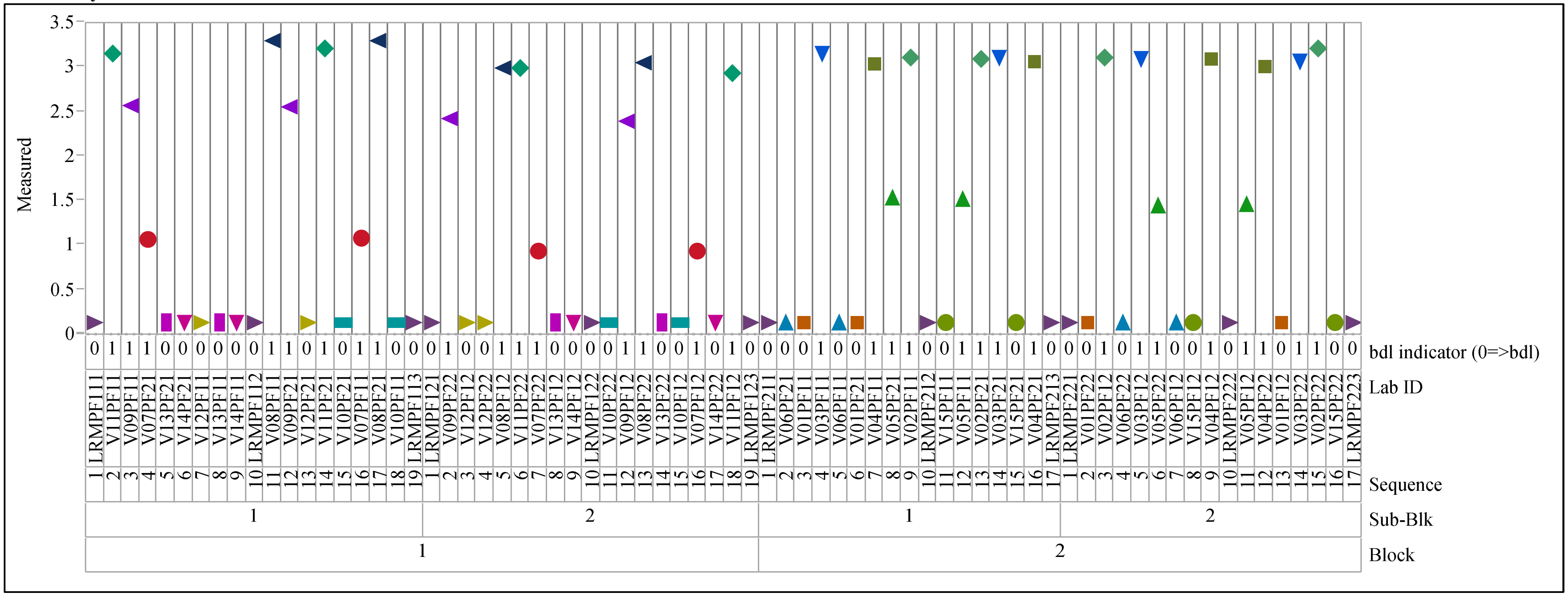


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Analyte=Na2O (wt%), Prep Method=AD
Variability Chart for Measured

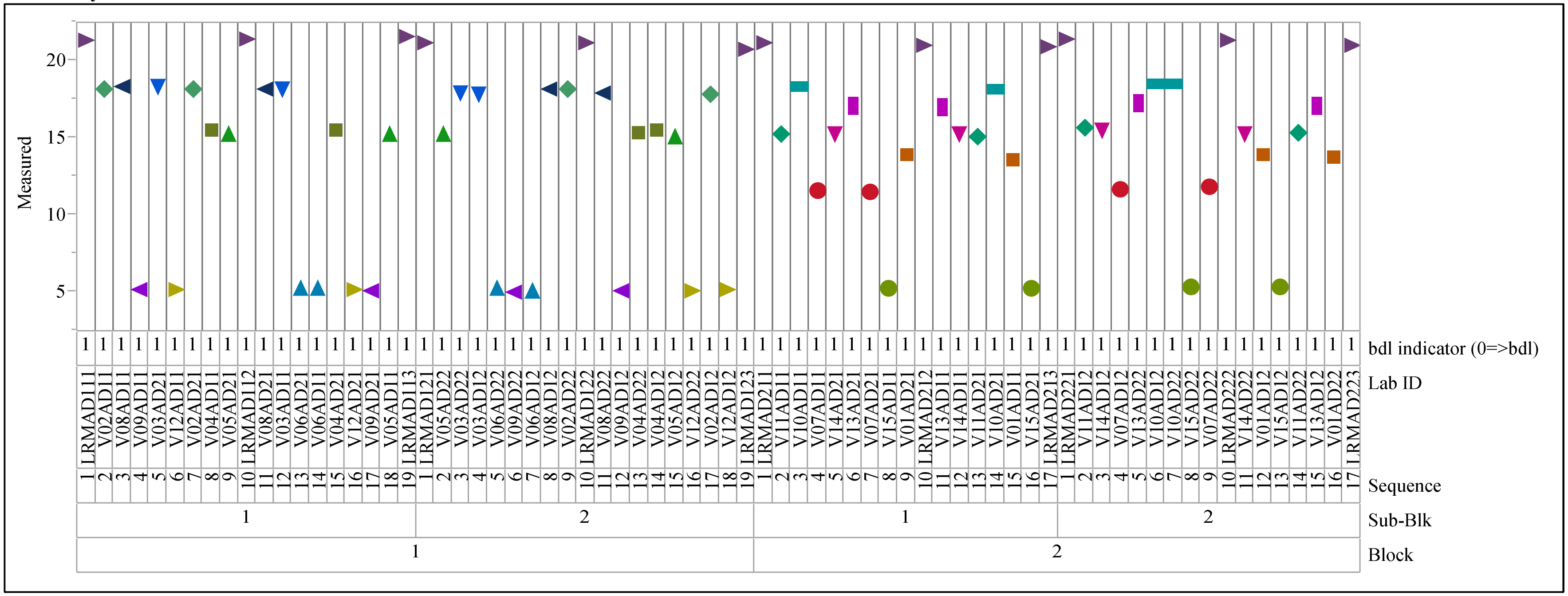


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Analyte=NiO (wt%), Prep Method=PF
Variability Chart for Measured

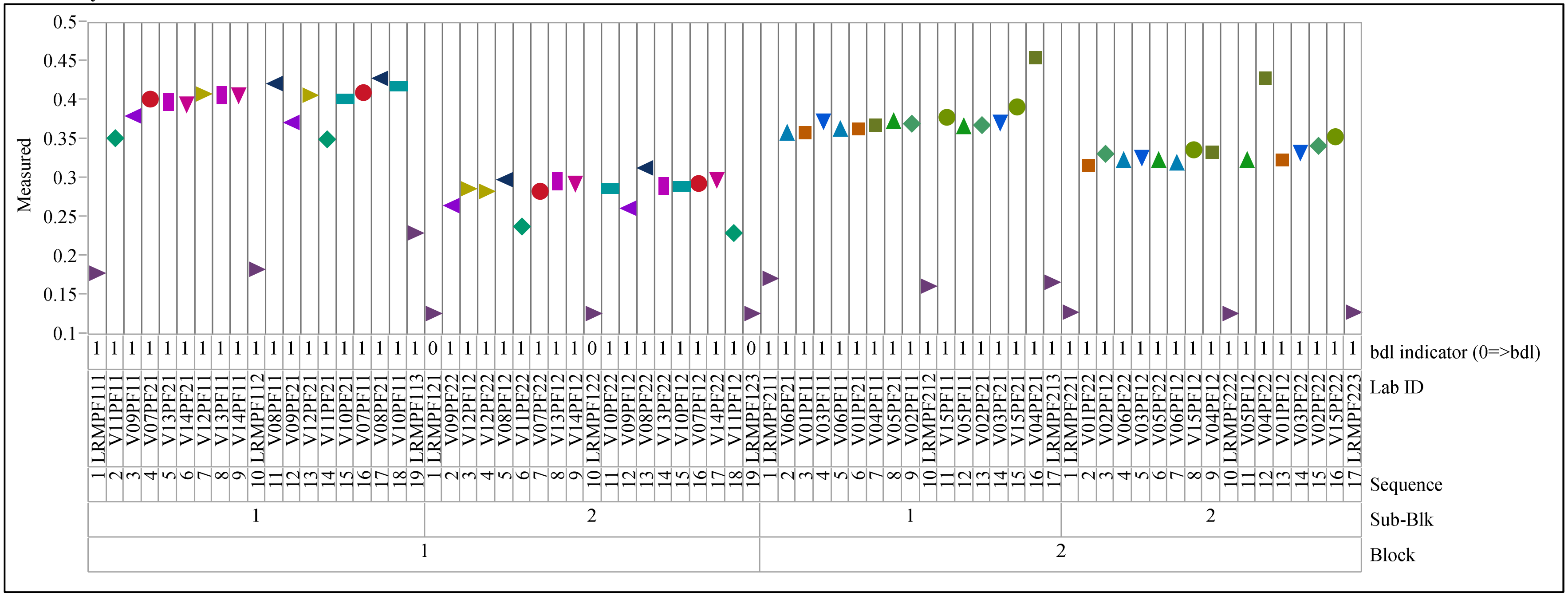


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Analyte=P2O5 (wt%), Prep Method=AD
Variability Chart for Measured

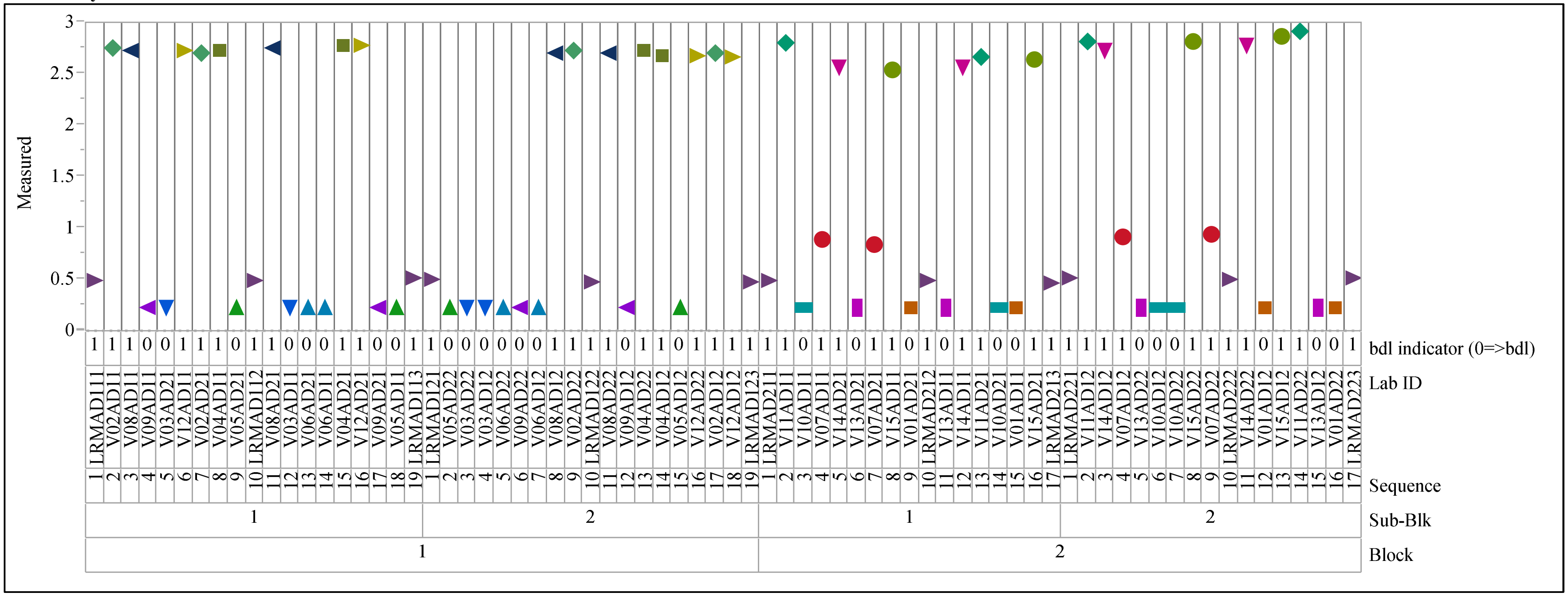


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Analyte=PbO (wt%), Prep Method=AD
Variability Chart for Measured

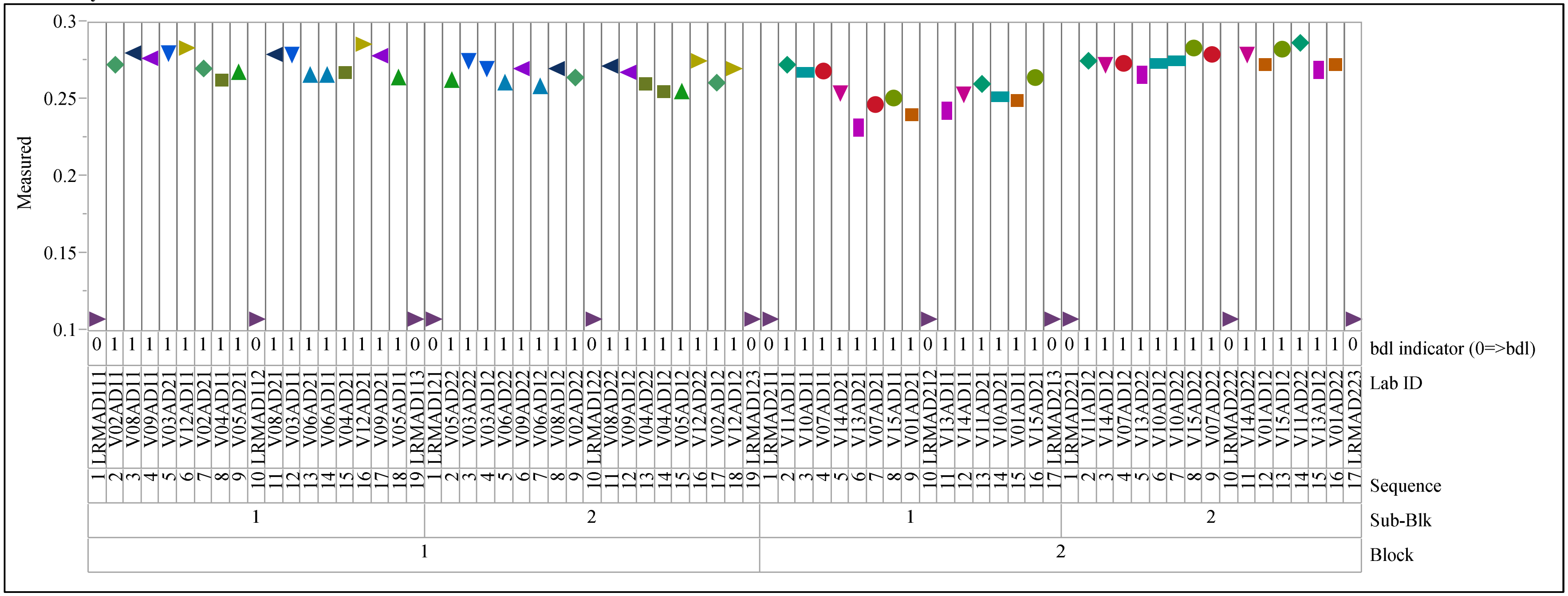


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Analyte=RuO2 (wt%), Prep Method=AD
Variability Chart for Measured

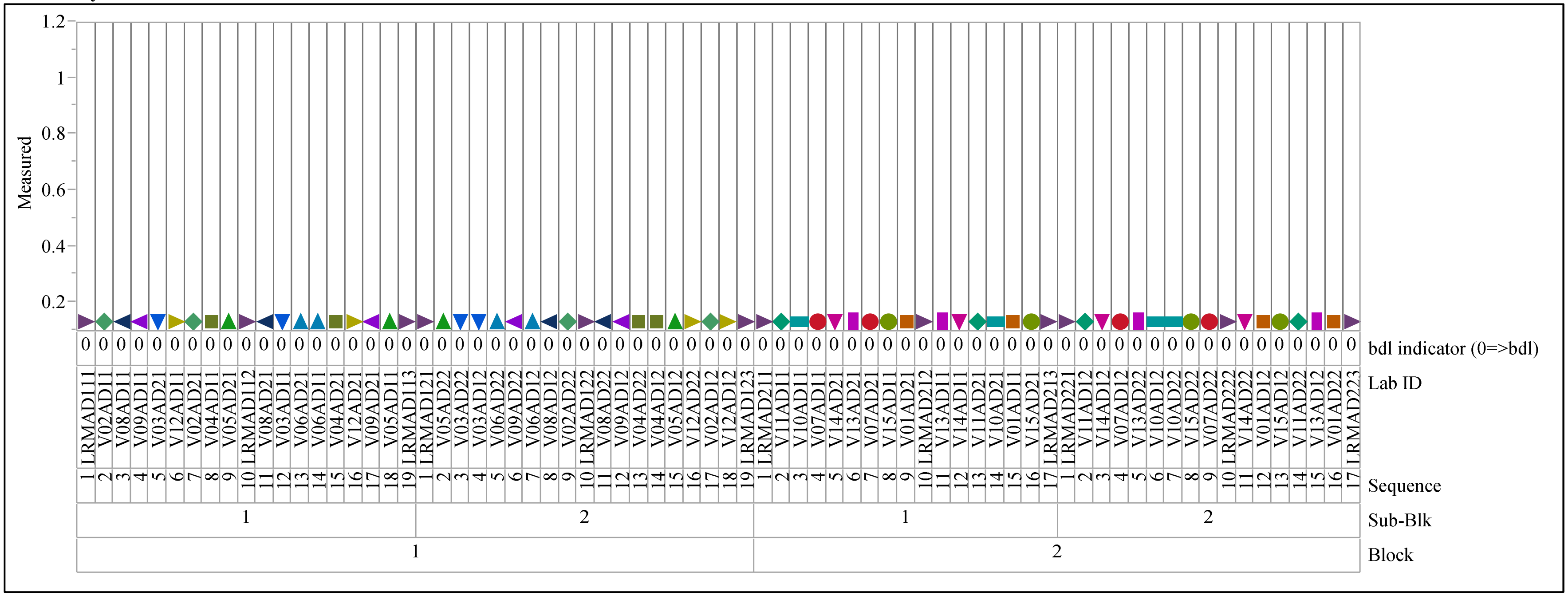


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Analyte=SiO2 (wt%), Prep Method=PF
Variability Chart for Measured

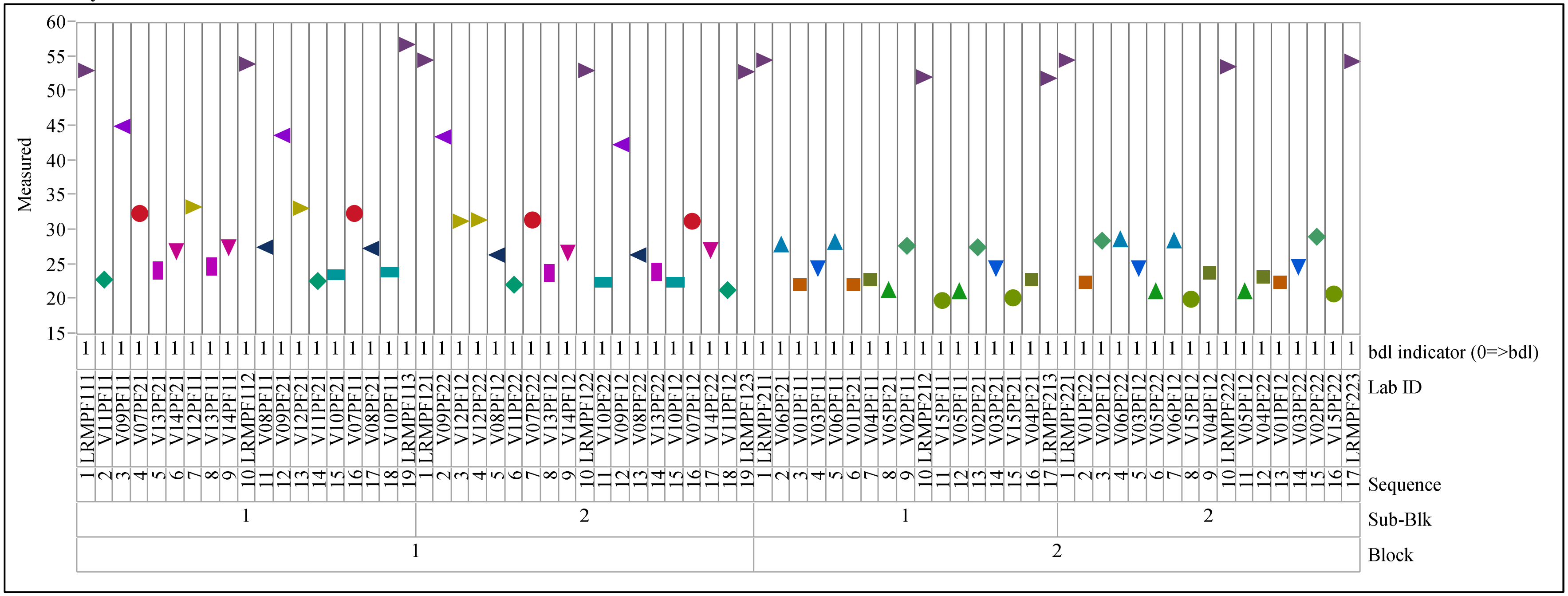


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Analyte=SO3 (wt%), Prep Method=AD
Variability Chart for Measured

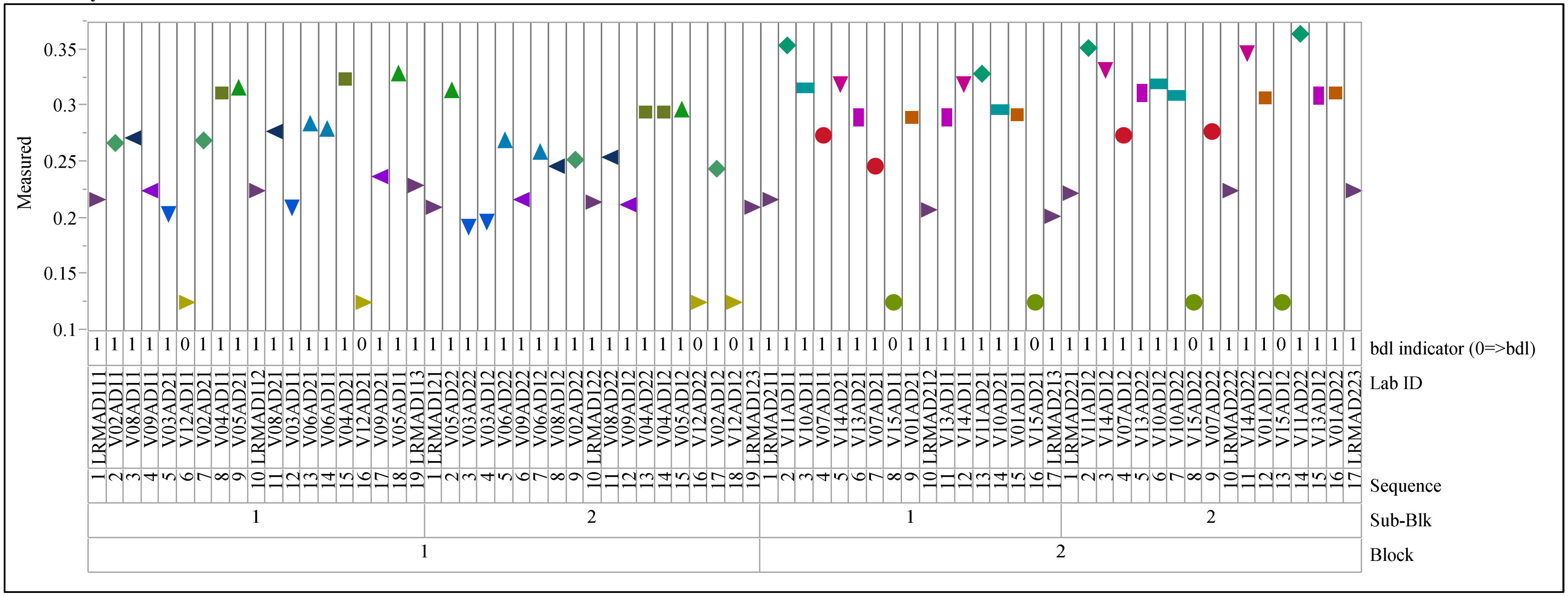


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Analyte=SrO (wt%), Prep Method=AD
Variability Chart for Measured

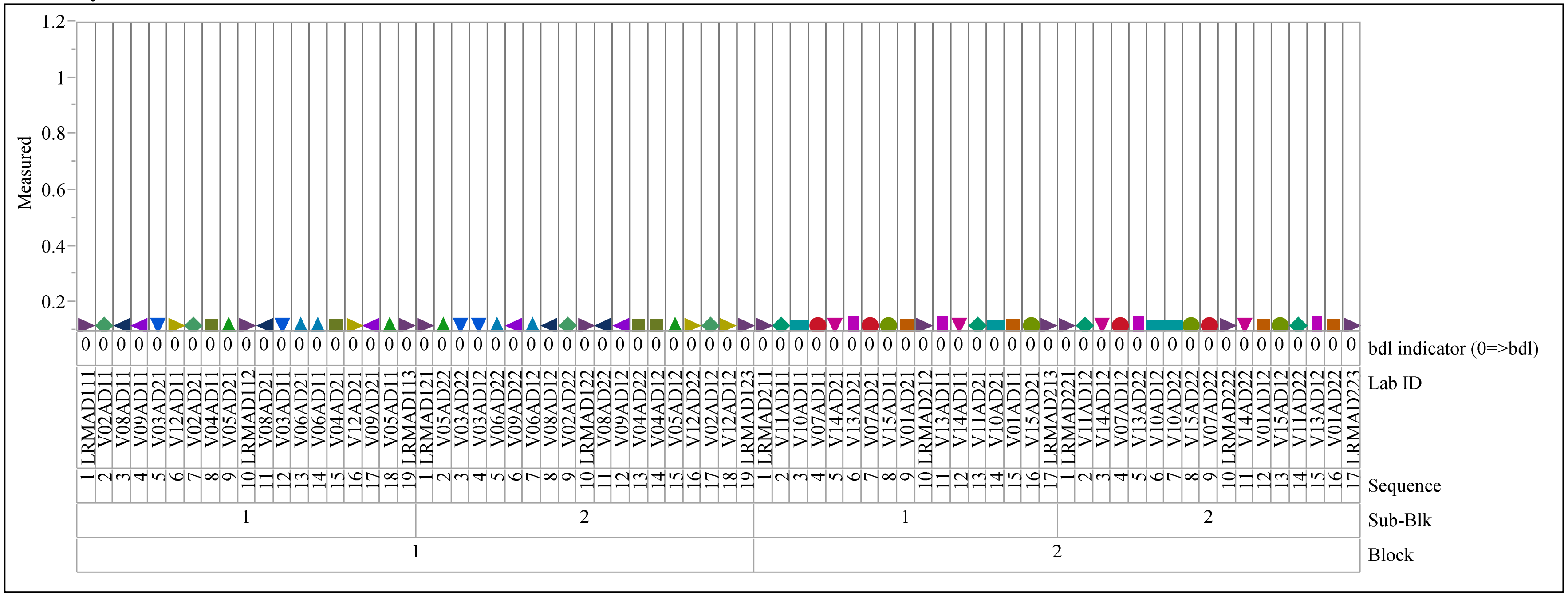


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Analyte=ZrO2 (wt%), Prep Method=AD
Variability Chart for Measured

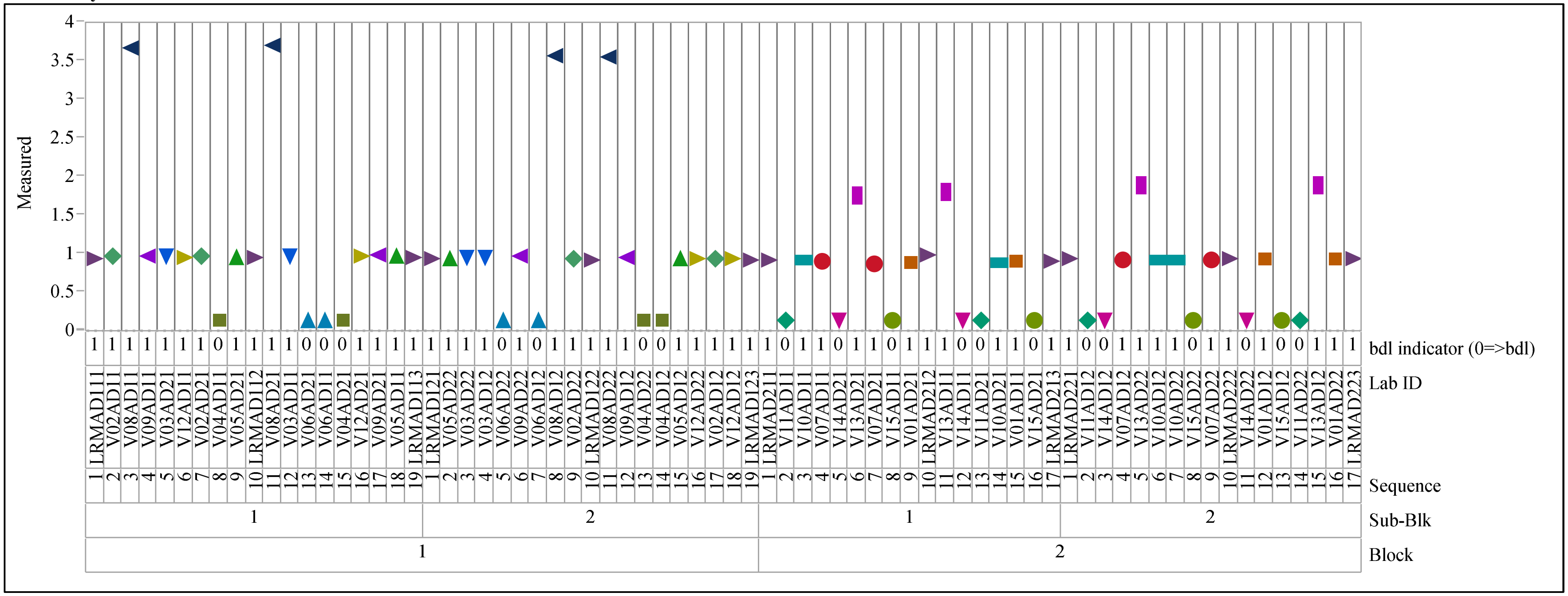


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier Grouped by Targeted Concentrations

Analyte=Al2O3 (wt%), Prep Method=PF
Variability Chart for Measured

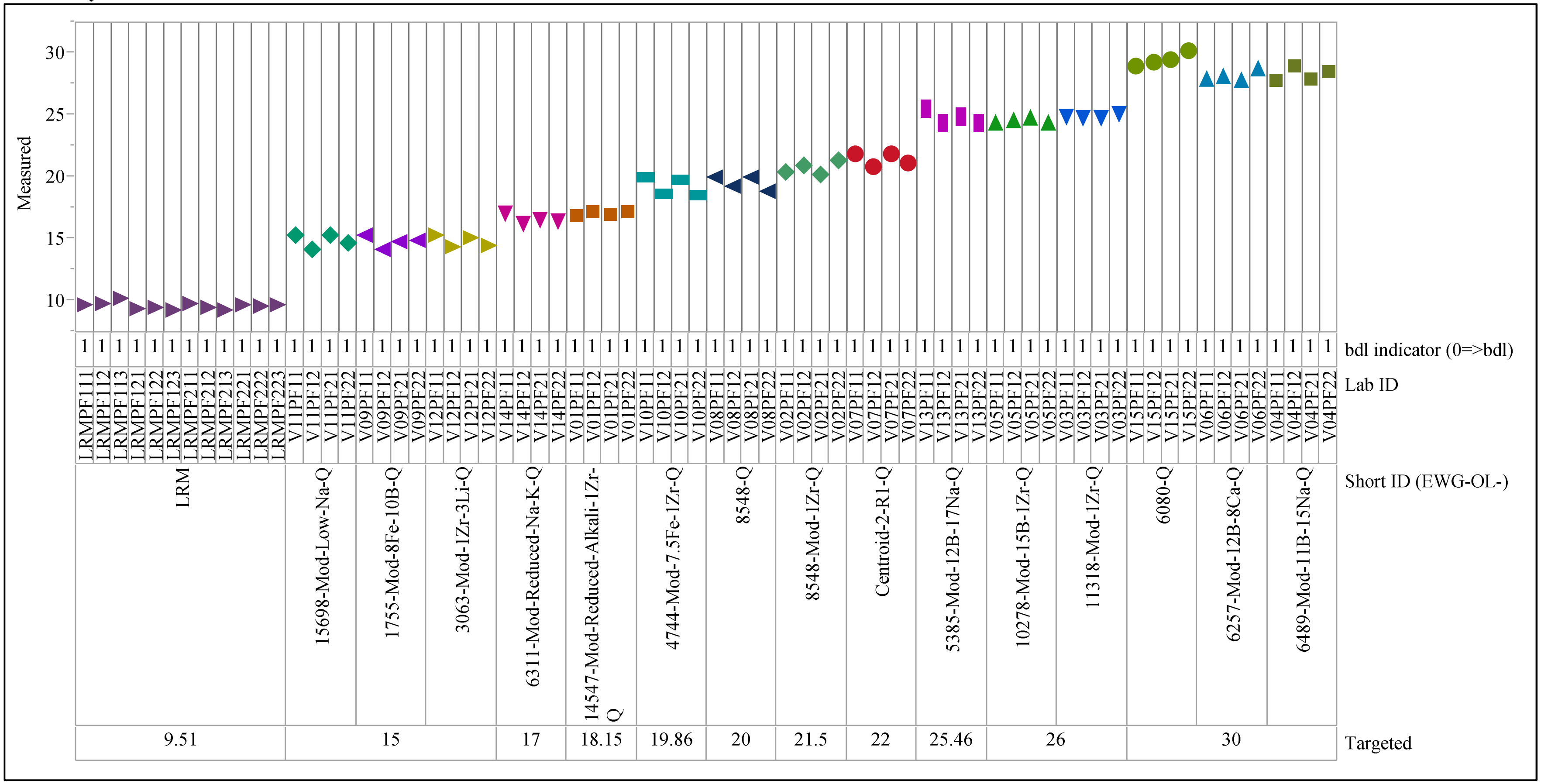


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier Grouped by Targeted Concentrations (continued)

Analyte=B2O3 (wt%), Prep Method=PF
Variability Chart for Measured

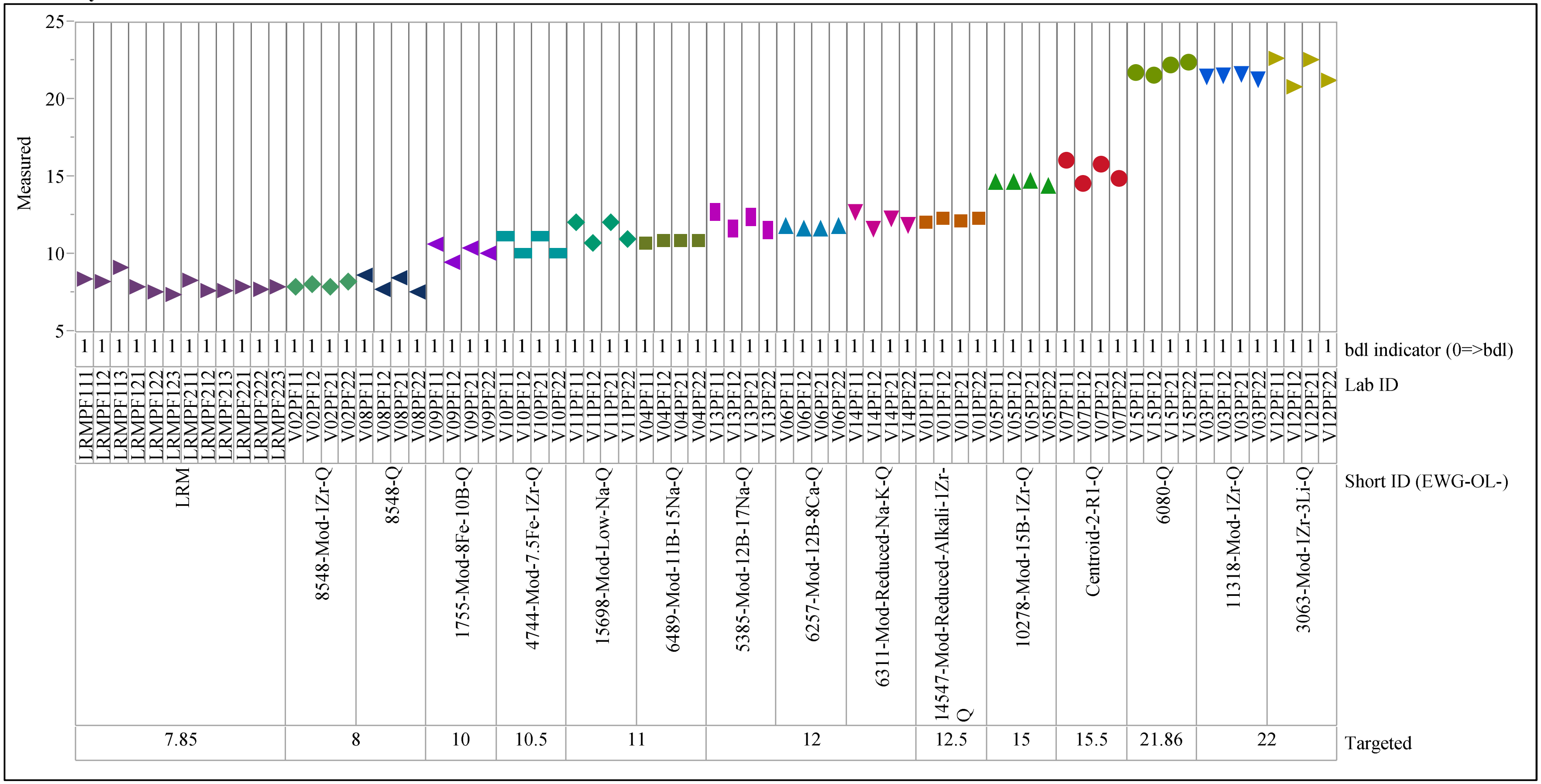


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier Grouped by Targeted Concentrations (continued)

Analyte=Bi2O3 (wt%), Prep Method=AD
Variability Chart for Measured

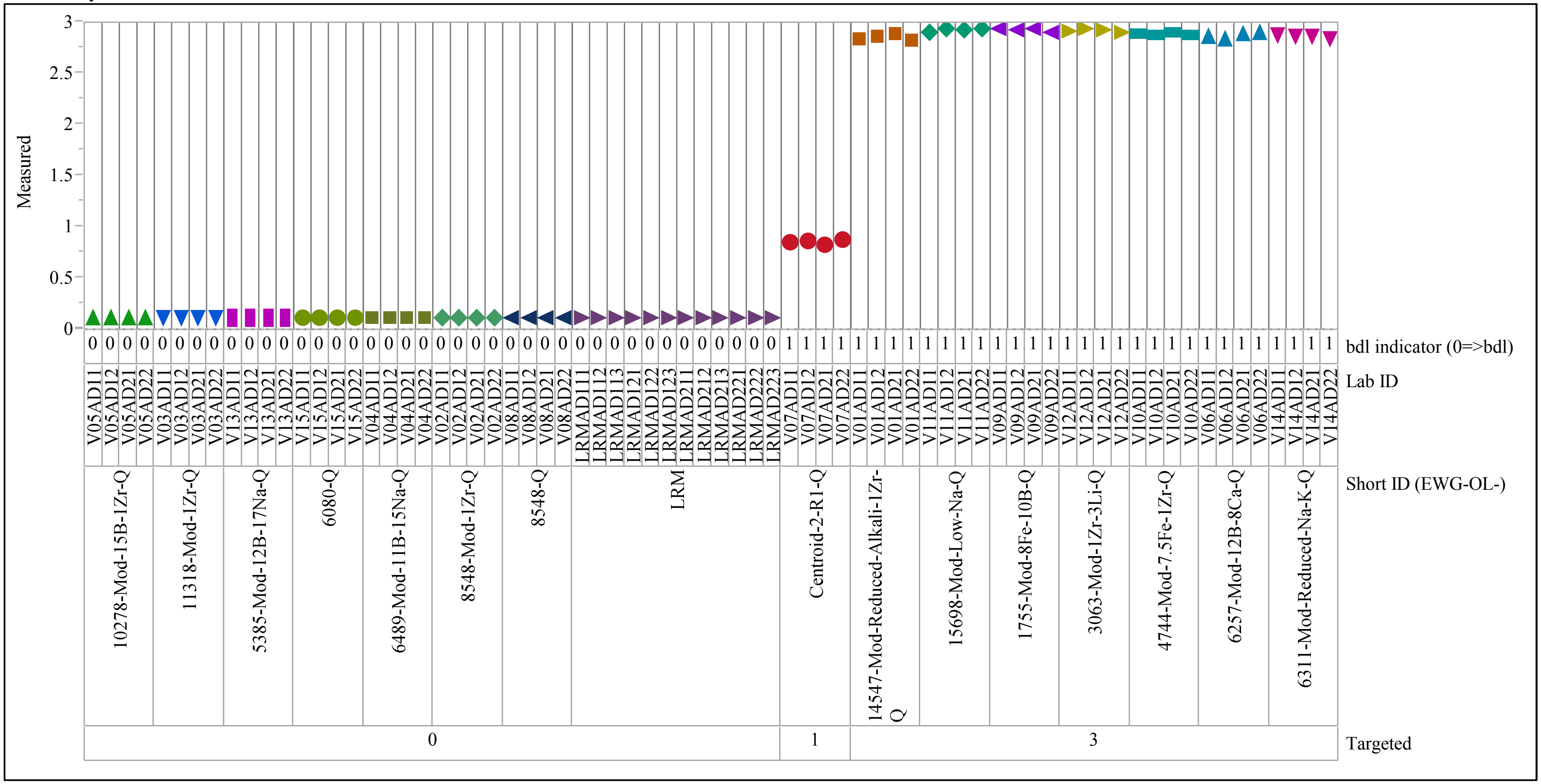


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier Grouped by Targeted Concentrations (continued)

Analyte=CaO (wt%), Prep Method=PF
Variability Chart for Measured

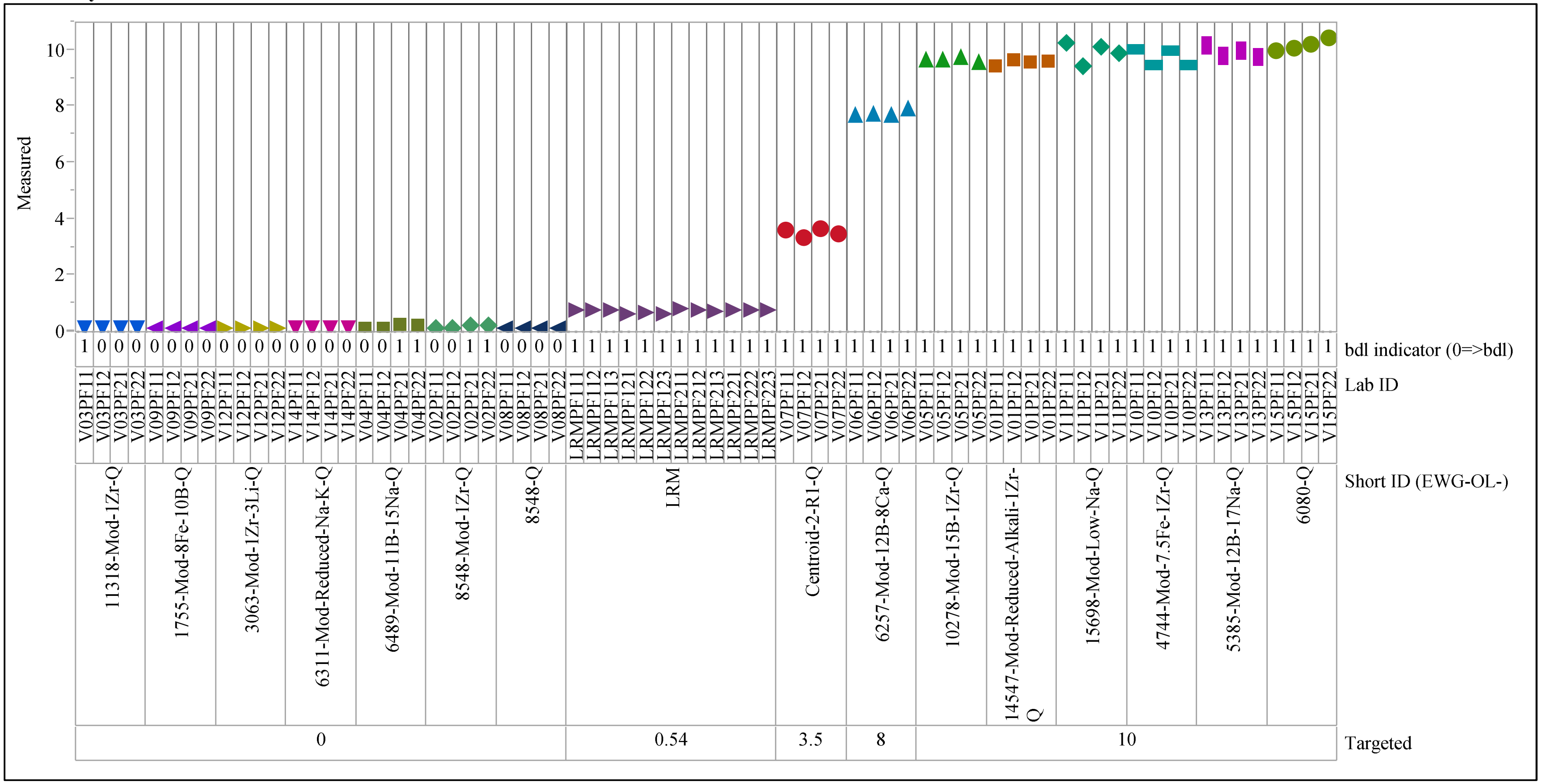


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier Grouped by Targeted Concentrations (continued)

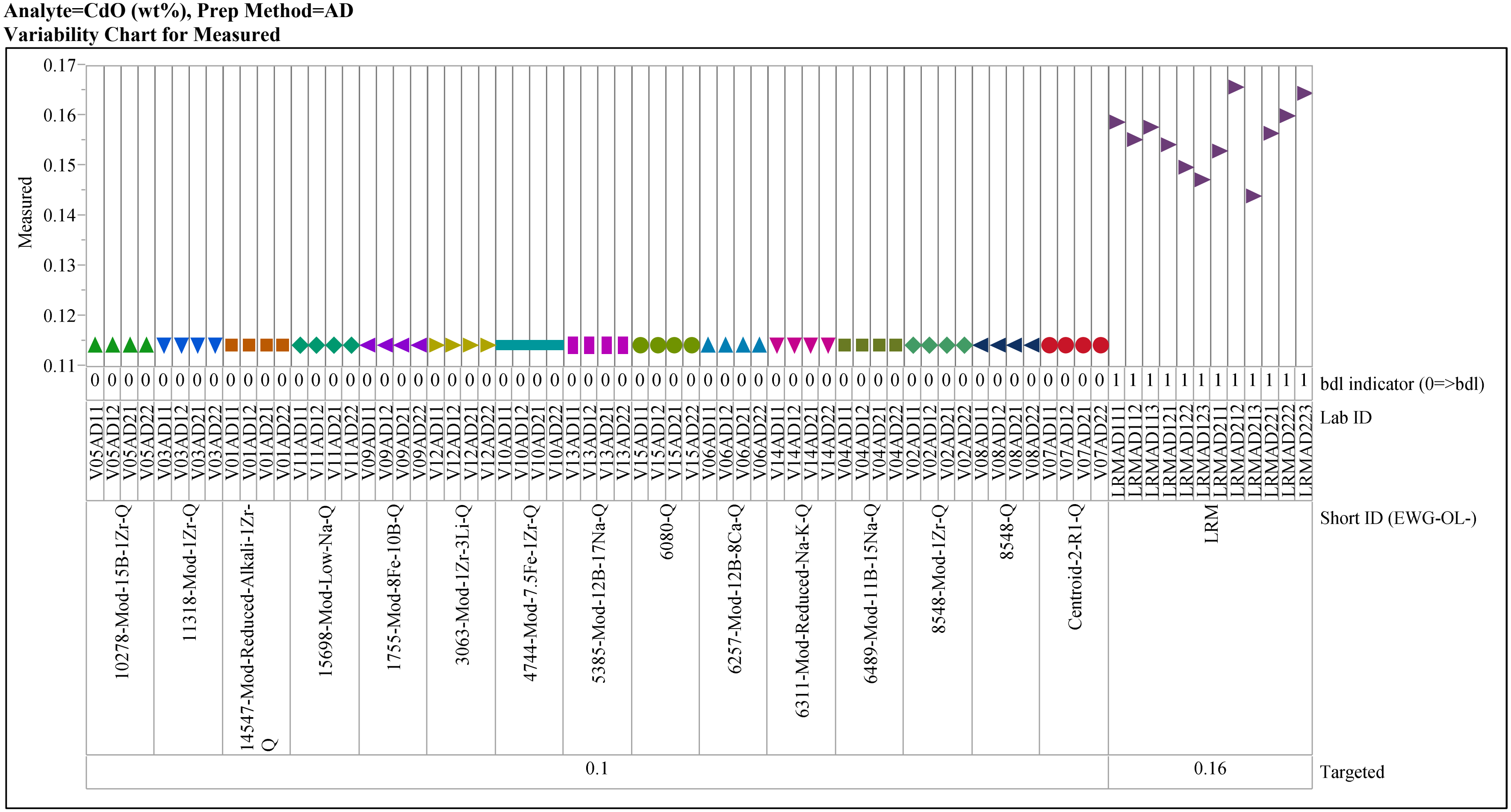


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier Grouped by Targeted Concentrations (continued)

Analyte=Cr2O3 (wt%), Prep Method=PF
Variability Chart for Measured

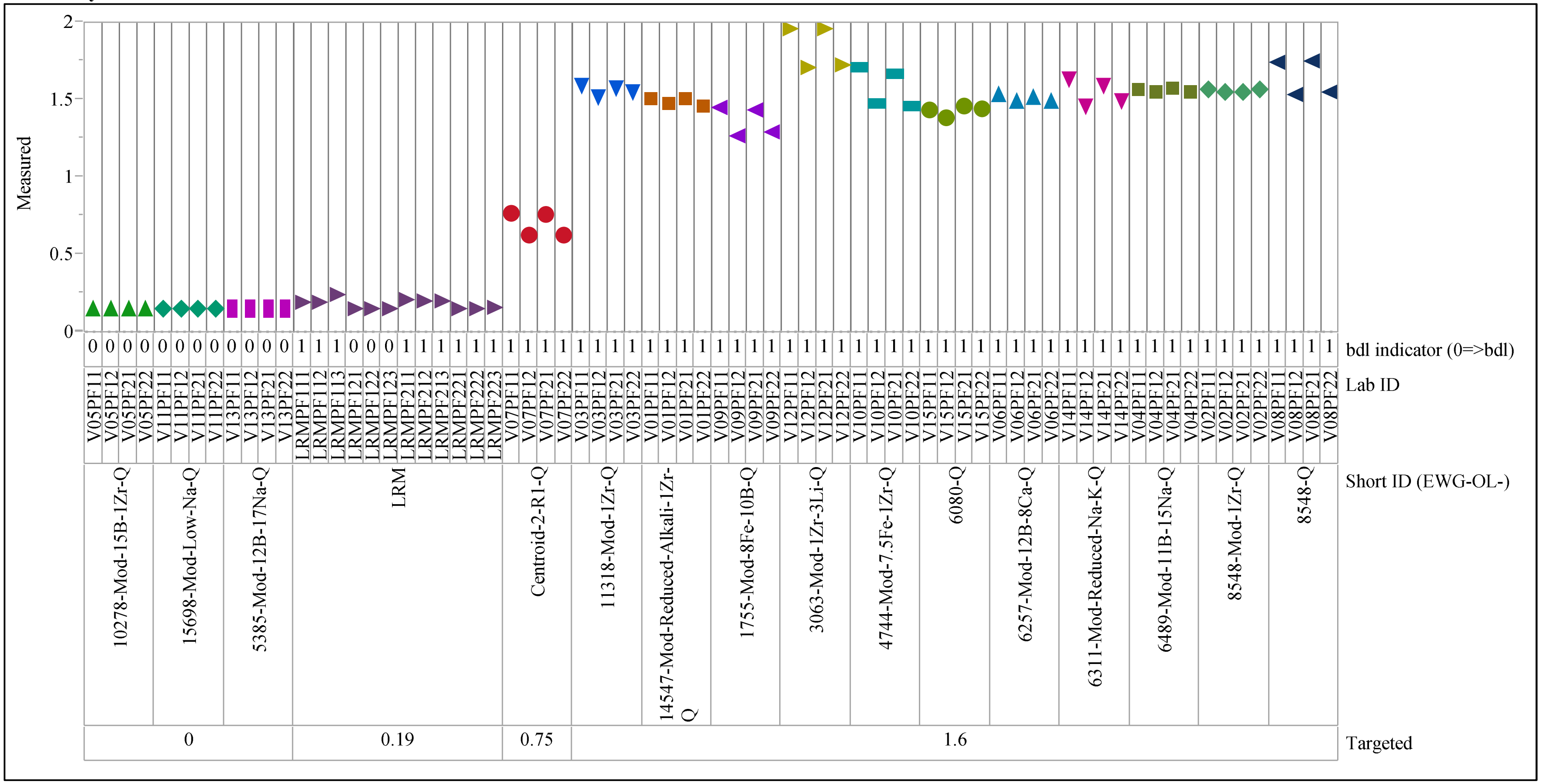


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier Grouped by Targeted Concentrations (continued)

Analyte=Fe2O3 (wt%), Prep Method=PF
Variability Chart for Measured

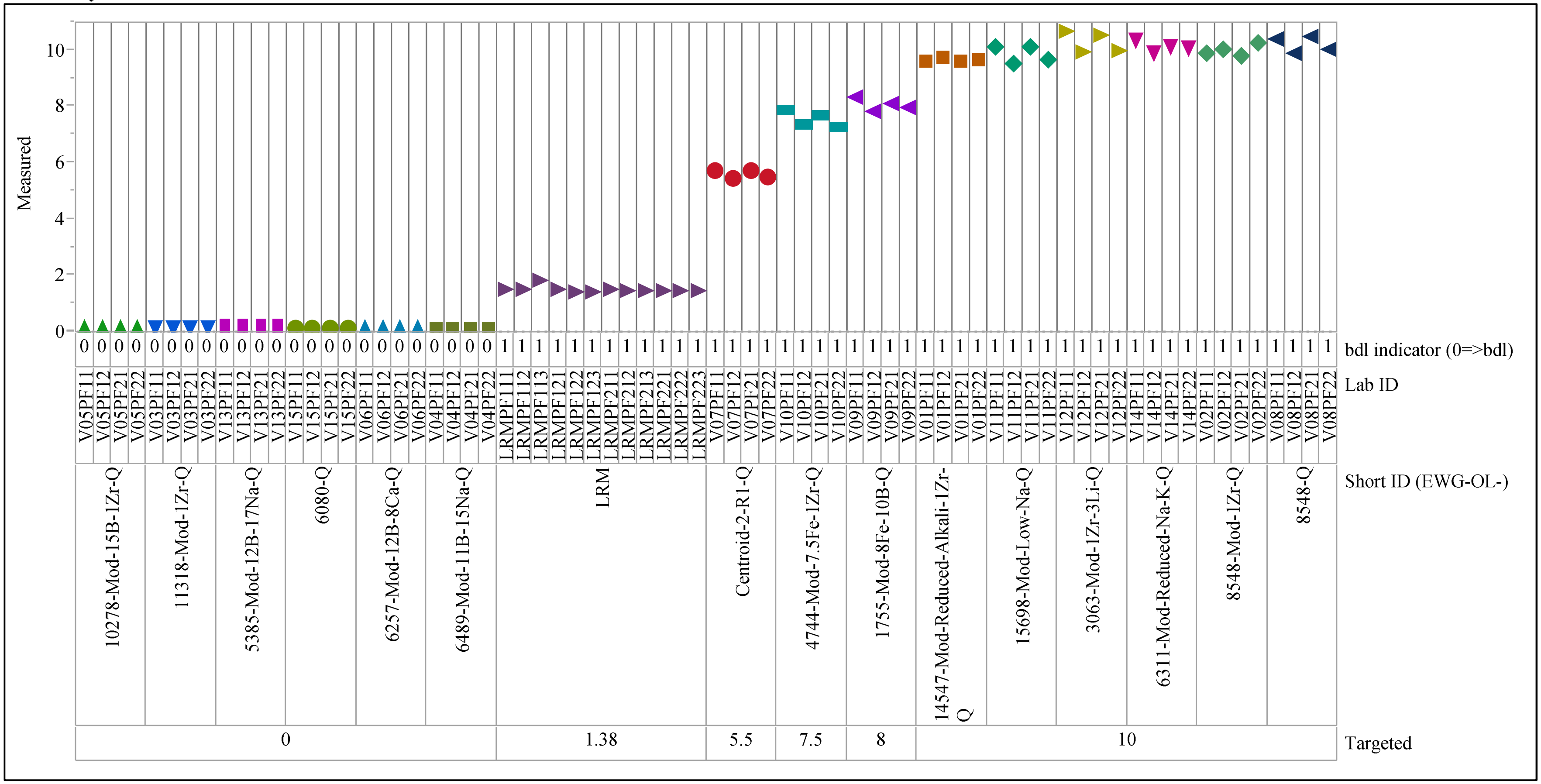


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier Grouped by Targeted Concentrations (continued)

Analyte=K2O (wt%), Prep Method=AD
Variability Chart for Measured

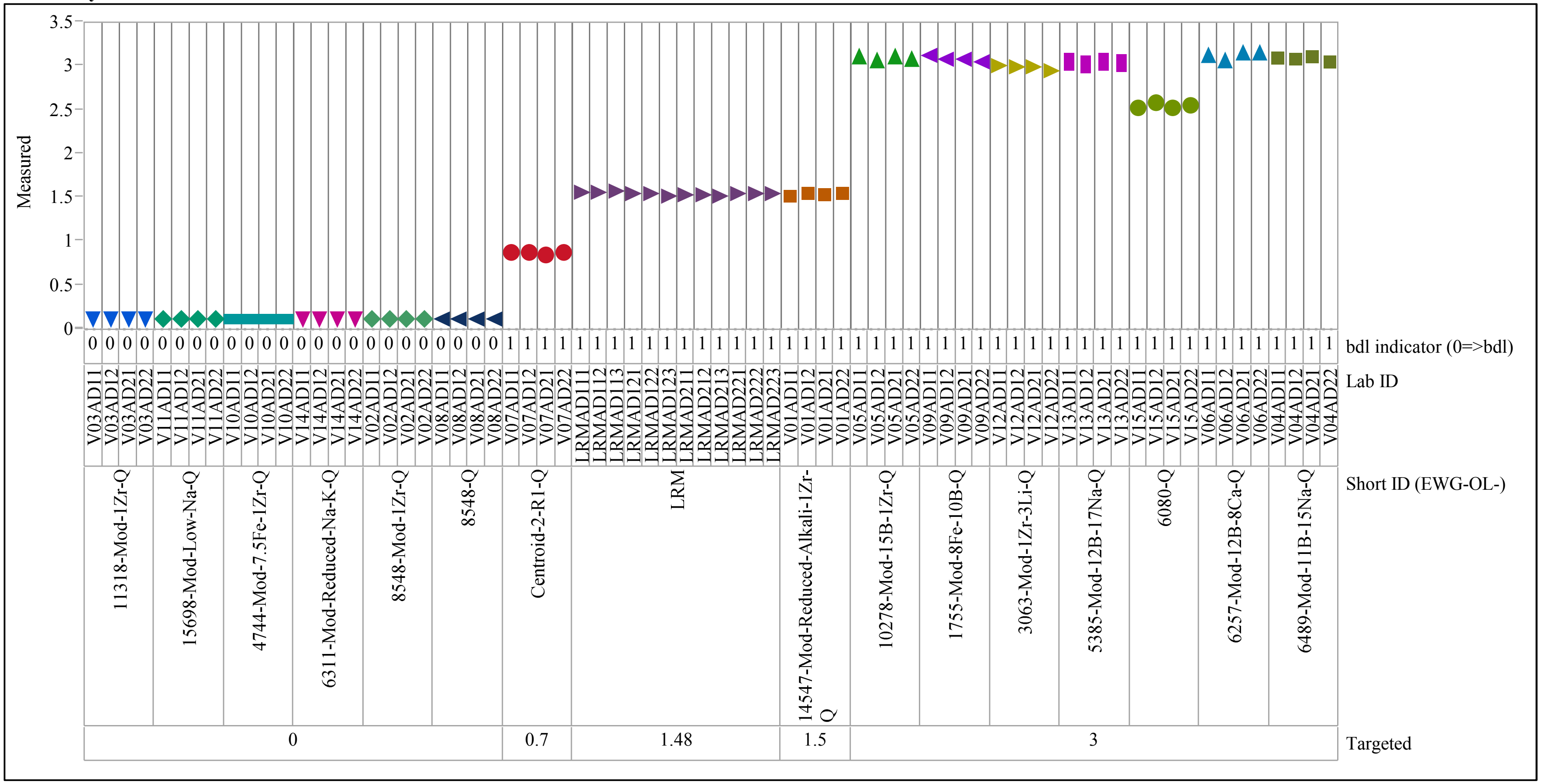


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier Grouped by Targeted Concentrations (continued)

Analyte=Li2O (wt%), Prep Method=PF
Variability Chart for Measured

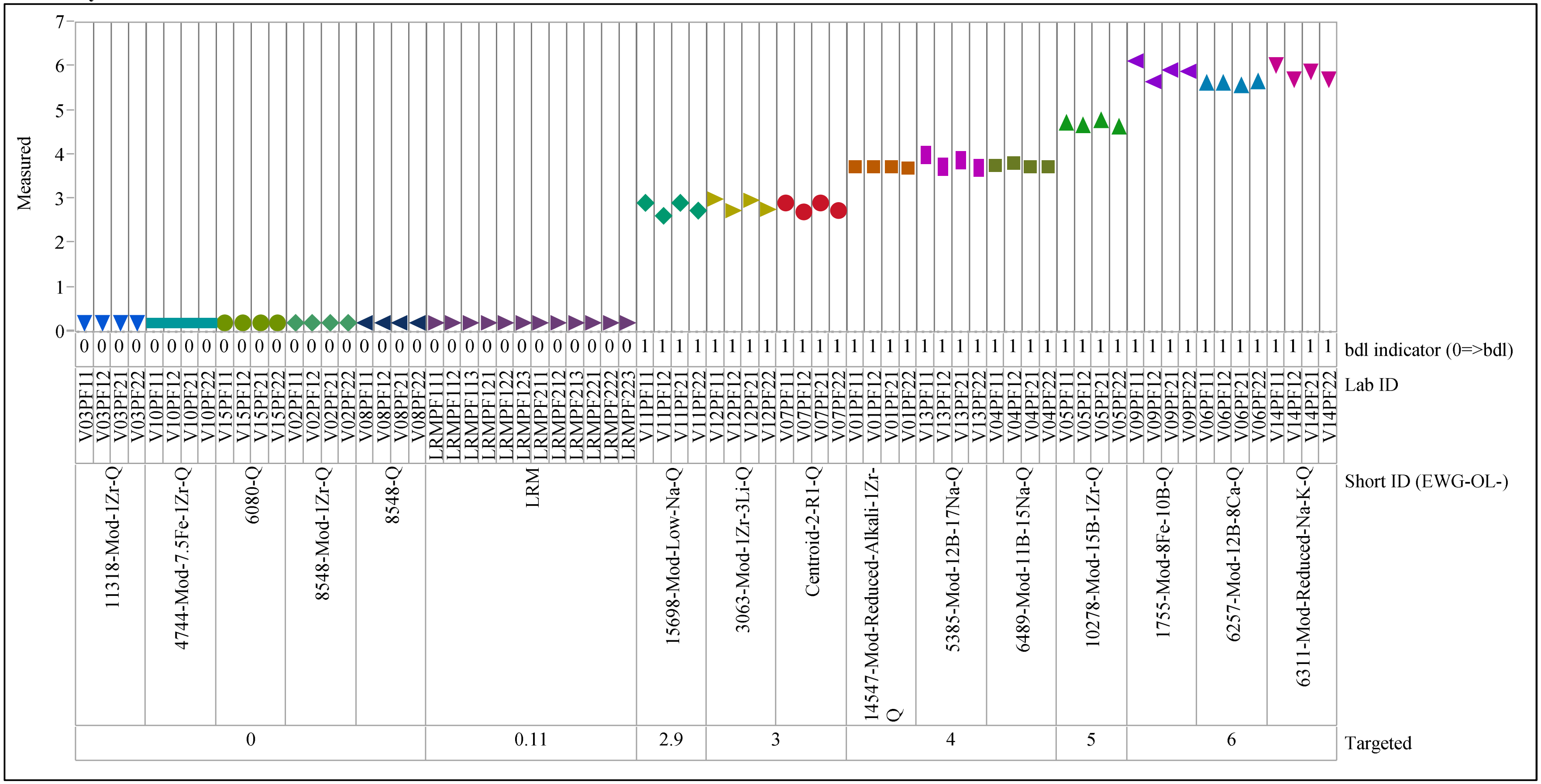


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier Grouped by Targeted Concentrations (continued)

Analyte=MgO (wt%), Prep Method=PF
Variability Chart for Measured

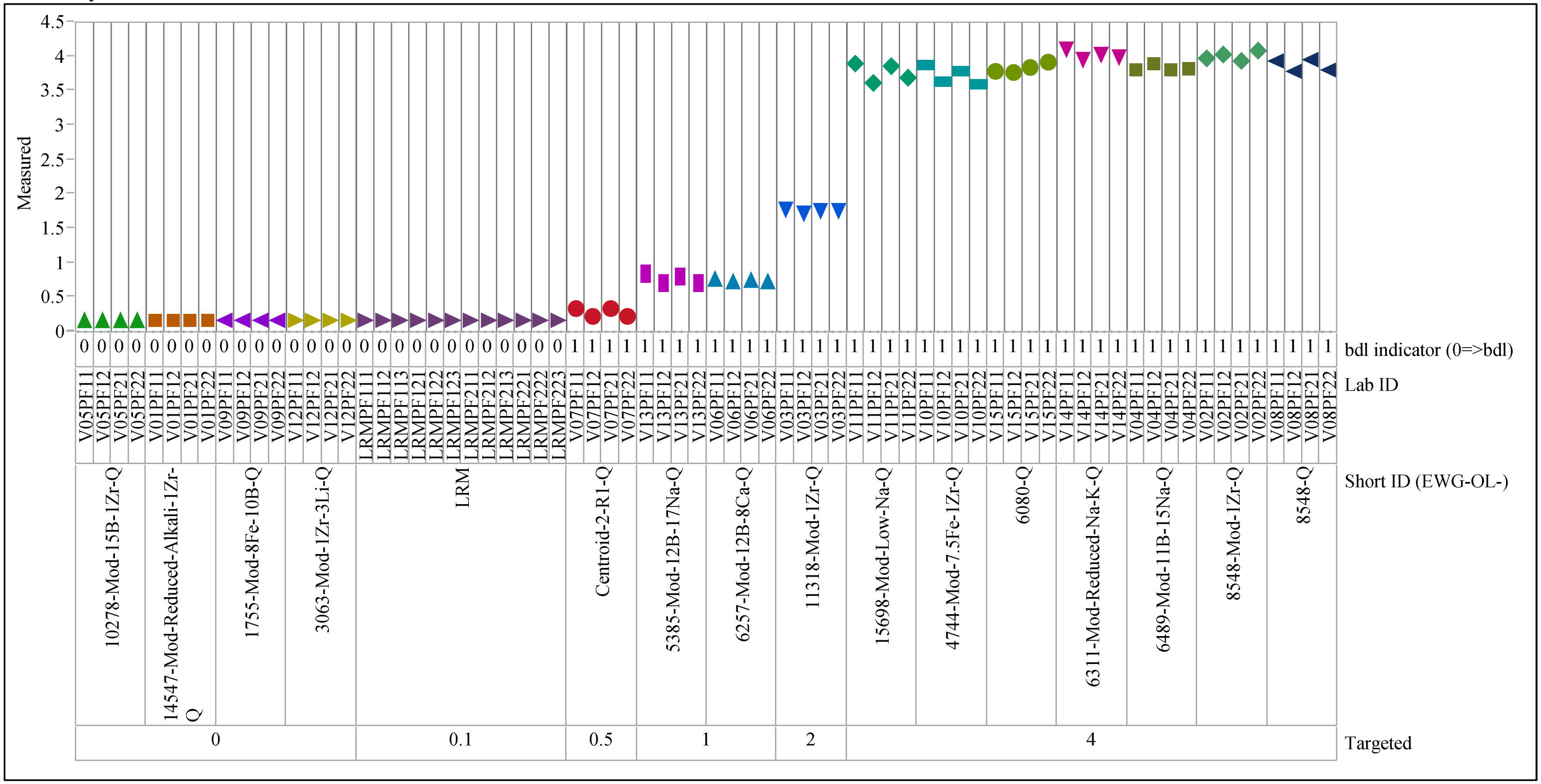


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier Grouped by Targeted Concentrations (continued)

Analyte=MnO (wt%), Prep Method=PF
Variability Chart for Measured

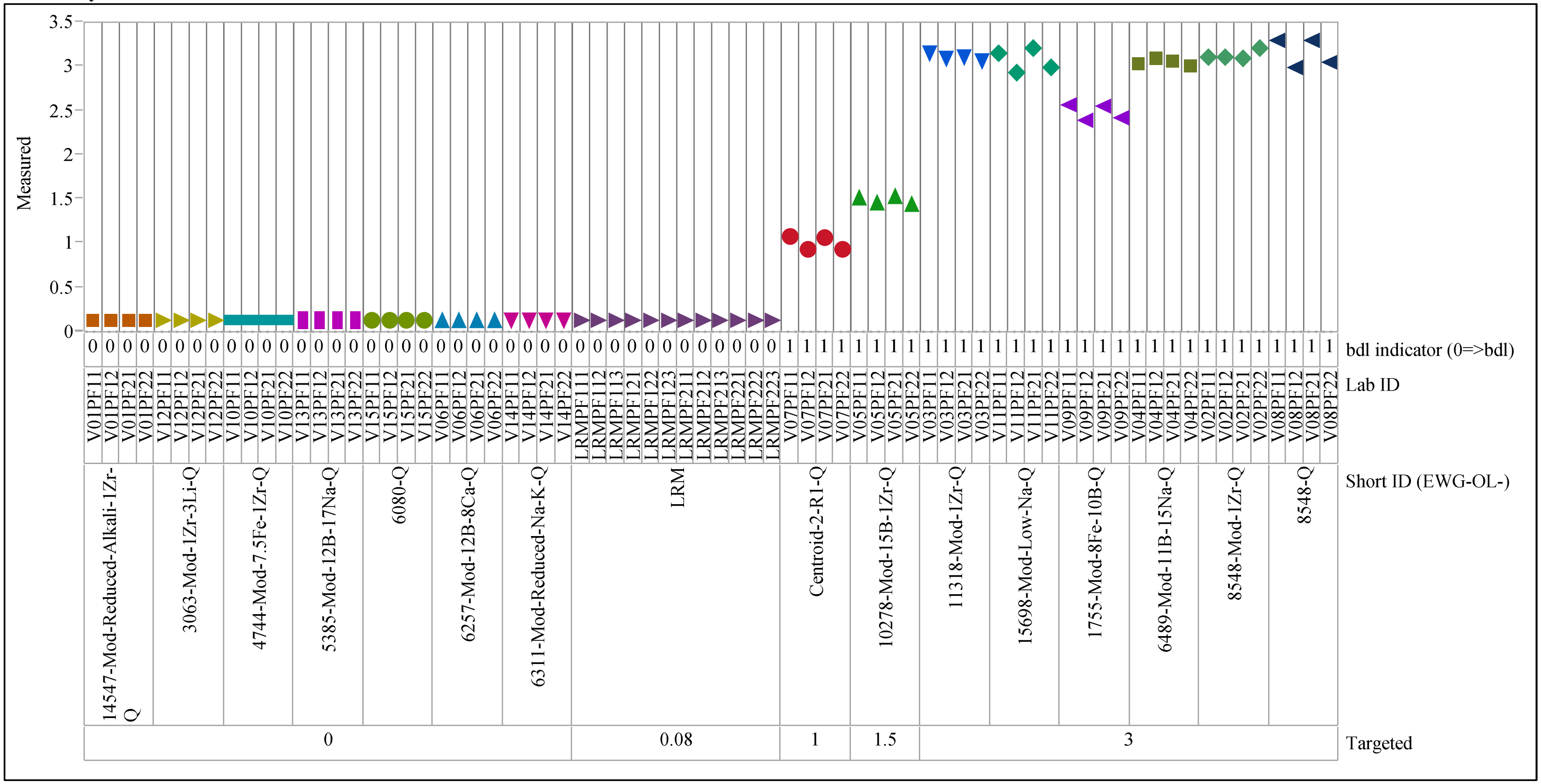


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier Grouped by Targeted Concentrations (continued)

Analyte=Na2O (wt%), Prep Method=AD
Variability Chart for Measured

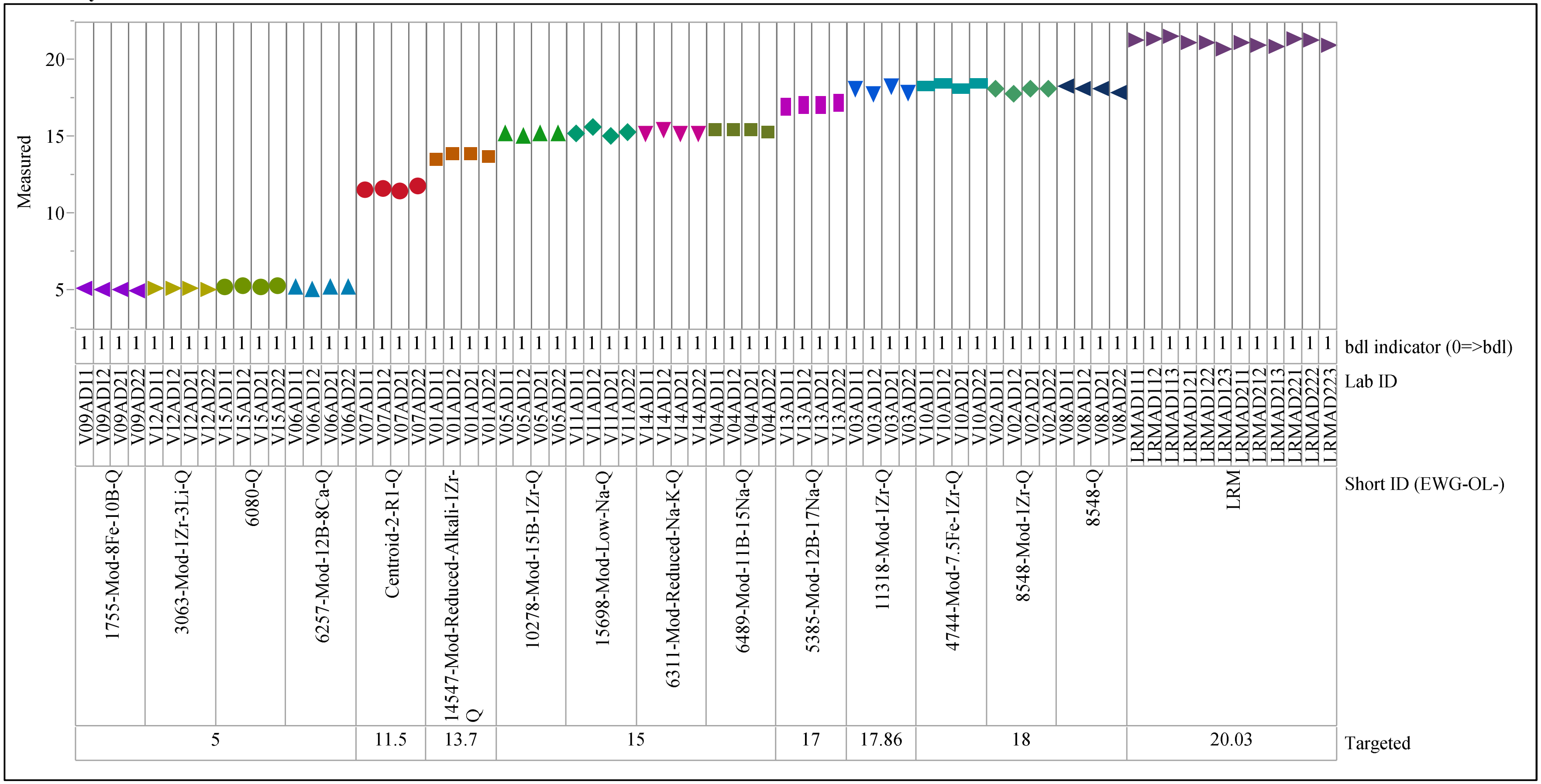


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier Grouped by Targeted Concentrations (continued)

Analyte=NiO (wt%), Prep Method=PF
Variability Chart for Measured

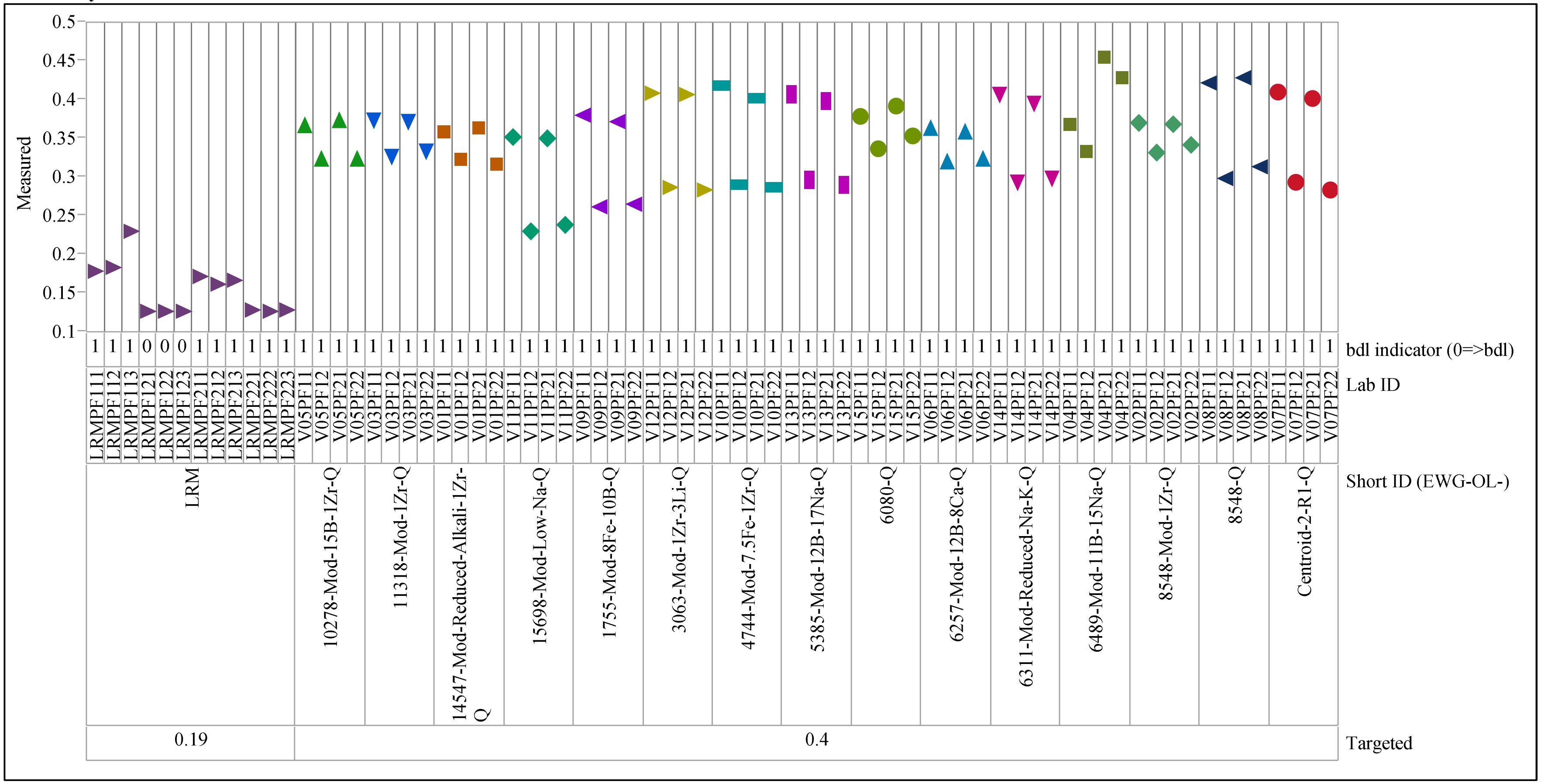


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier Grouped by Targeted Concentrations (continued)

Analyte=P2O5 (wt%), Prep Method=AD
Variability Chart for Measured

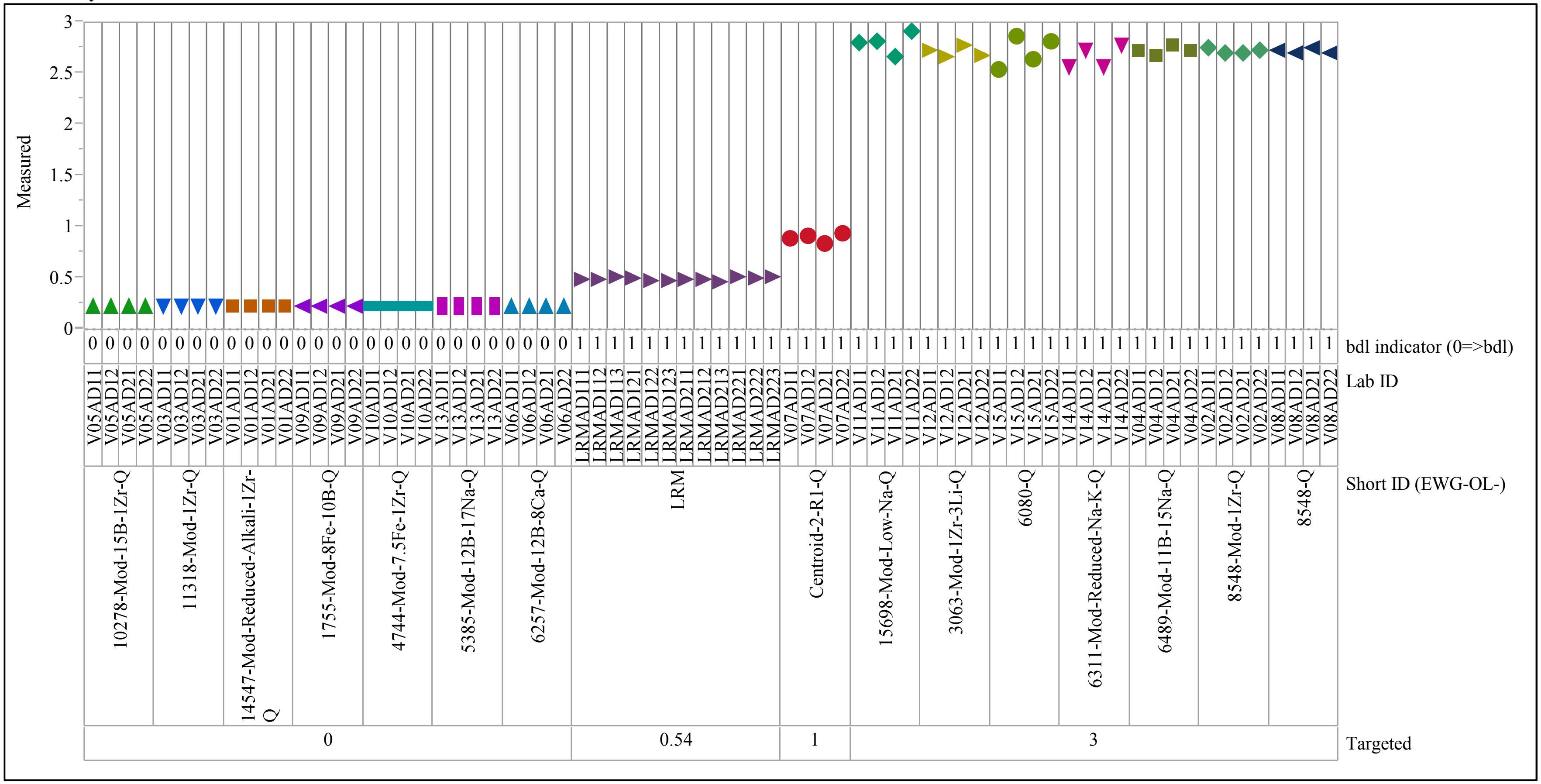


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier Grouped by Targeted Concentrations (continued)

Analyte=PbO (wt%), Prep Method=AD
Variability Chart for Measured

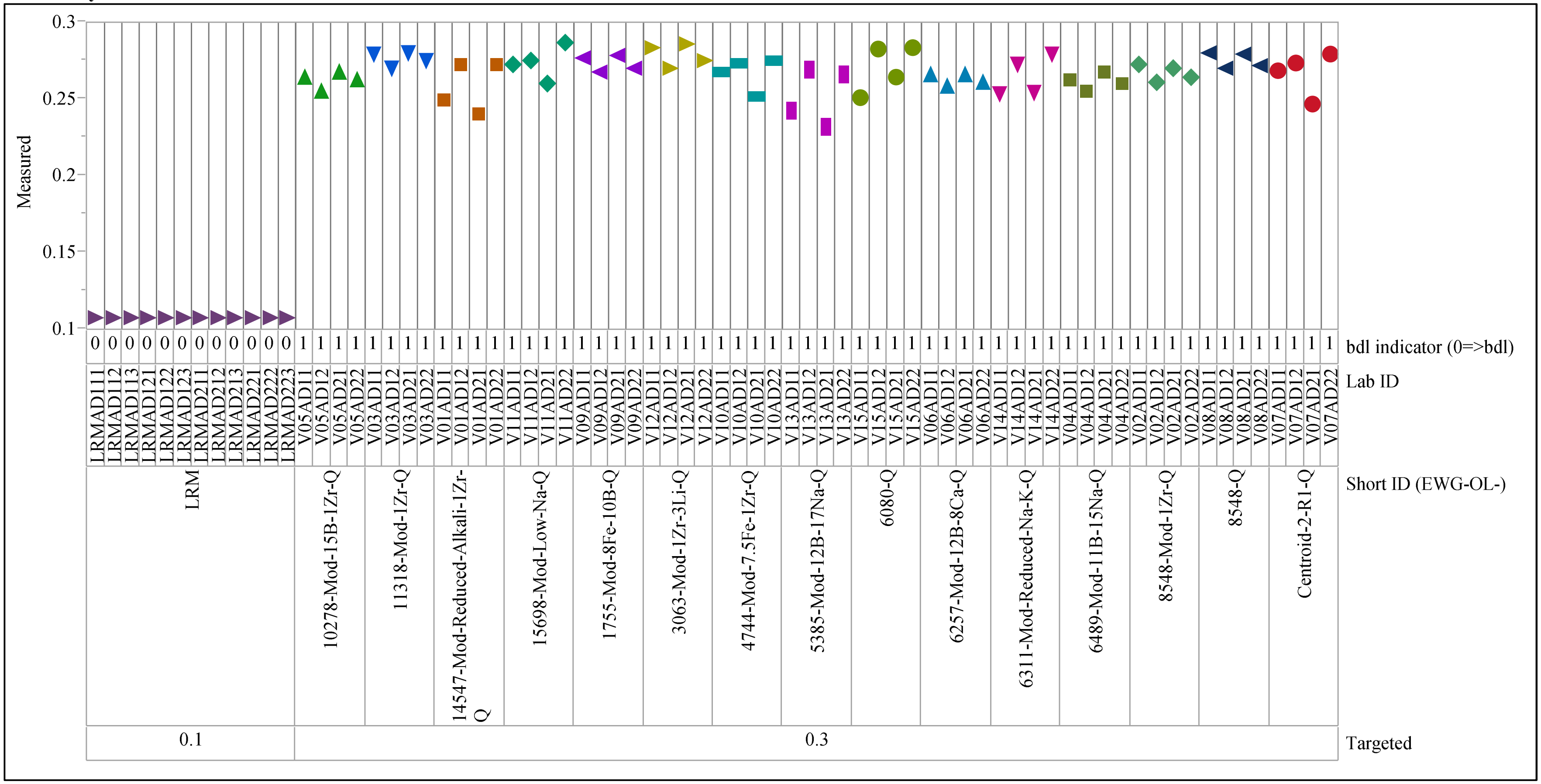


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier Grouped by Targeted Concentrations (continued)

Analyte=RuO2 (wt%), Prep Method=AD
Variability Chart for Measured

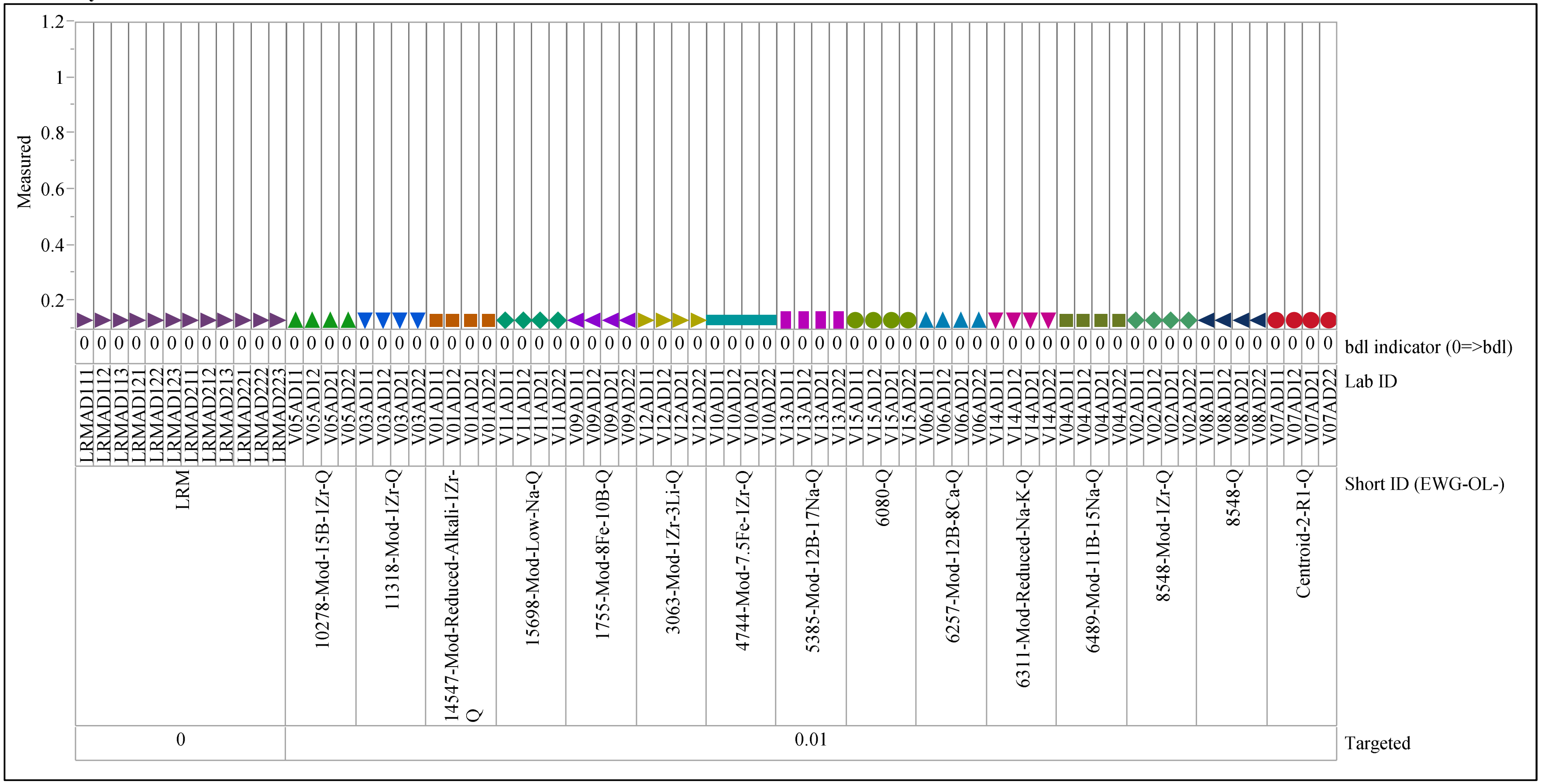


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier Grouped by Targeted Concentrations (continued)

Analyte=SiO2 (wt%), Prep Method=PF
Variability Chart for Measured

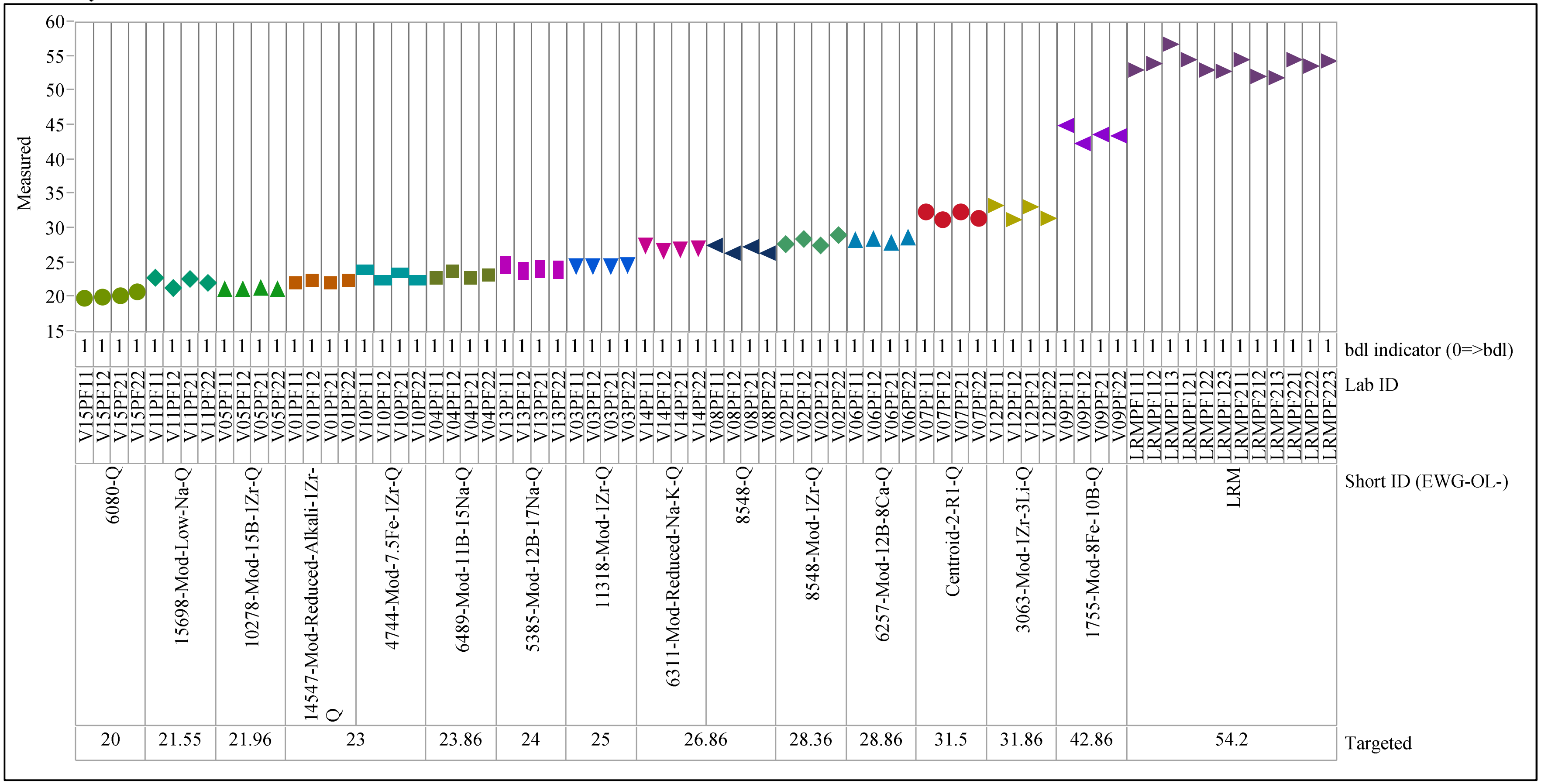


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier Grouped by Targeted Concentrations (continued)

Analyte=SO3 (wt%), Prep Method=AD
Variability Chart for Measured

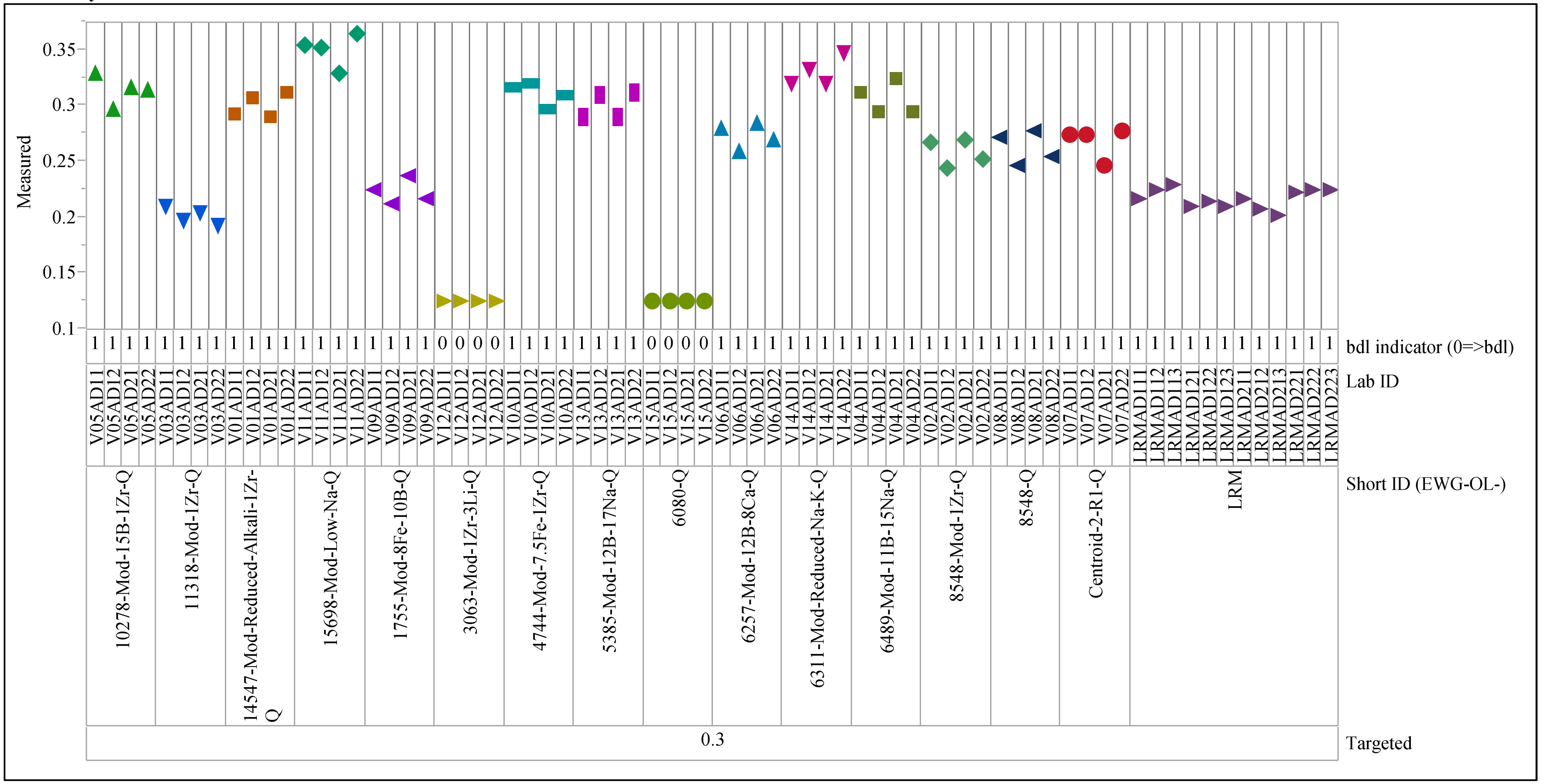


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier Grouped by Targeted Concentrations (continued)

Analyte=SrO (wt%), Prep Method=AD
Variability Chart for Measured

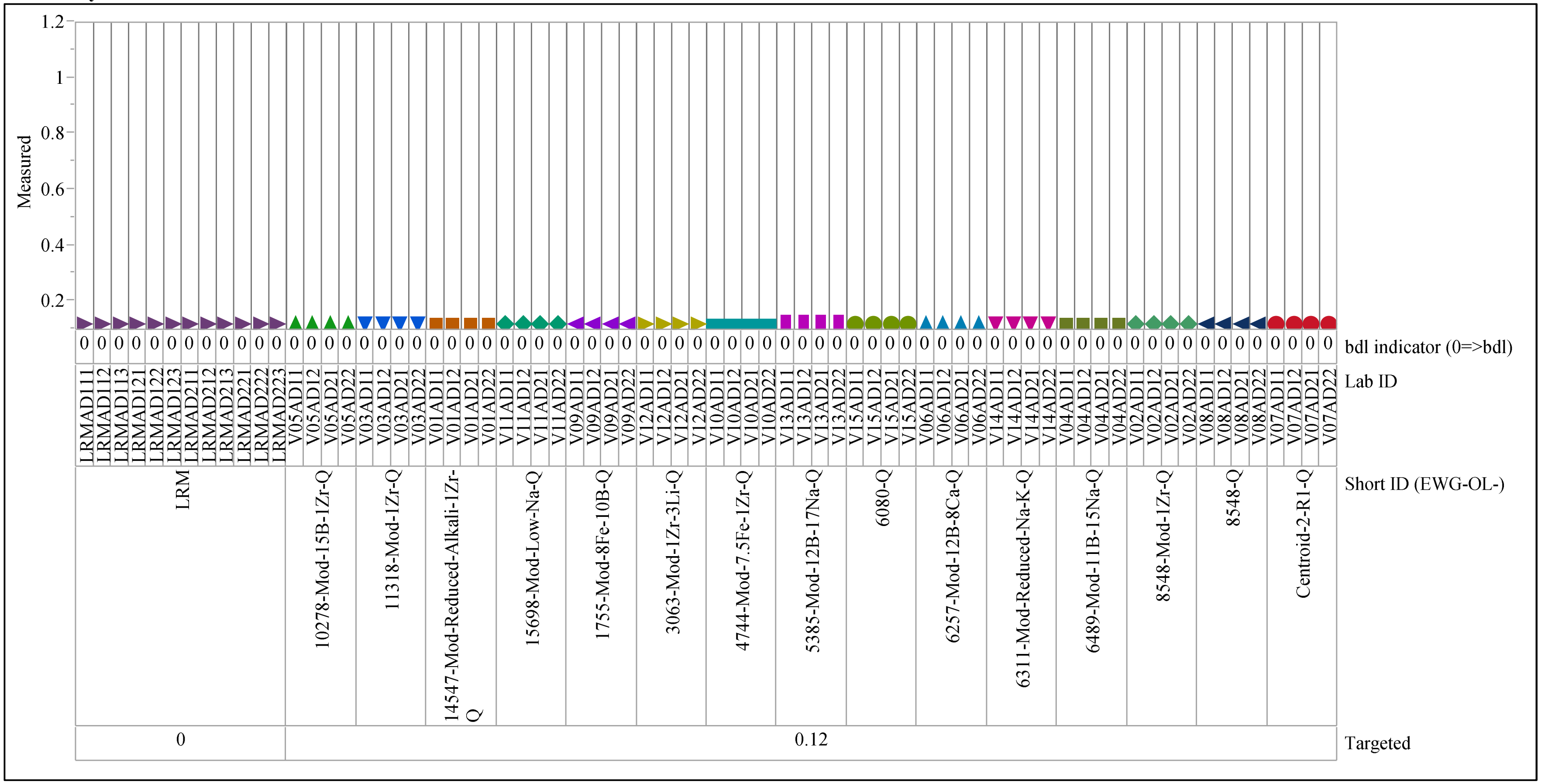


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier Grouped by Targeted Concentrations (continued)

Analyte=ZrO2 (wt%), Prep Method=AD
Variability Chart for Measured

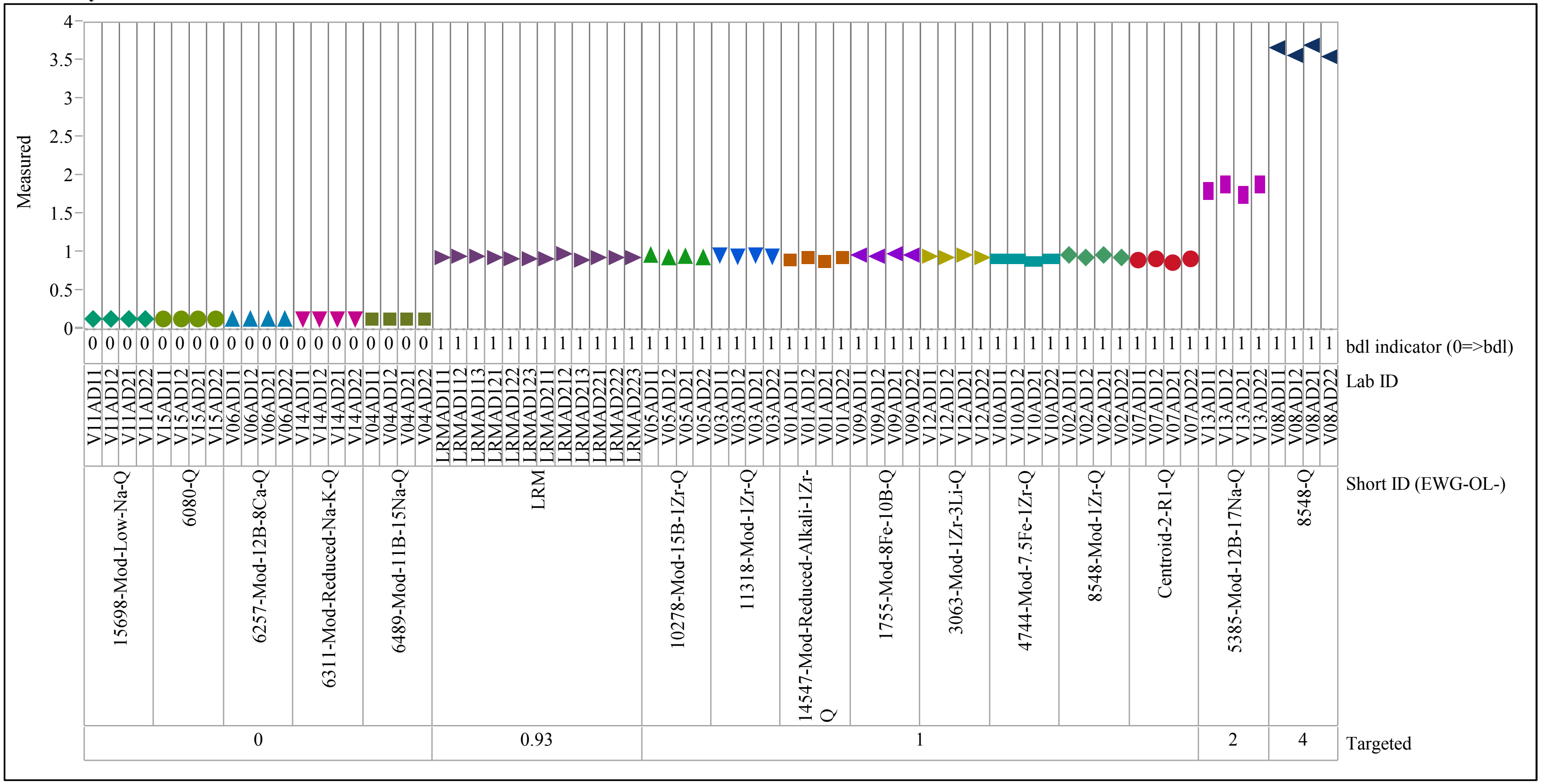


Exhibit A-3. Acceptability Evaluation for Measurements of the LRM Standard Glass

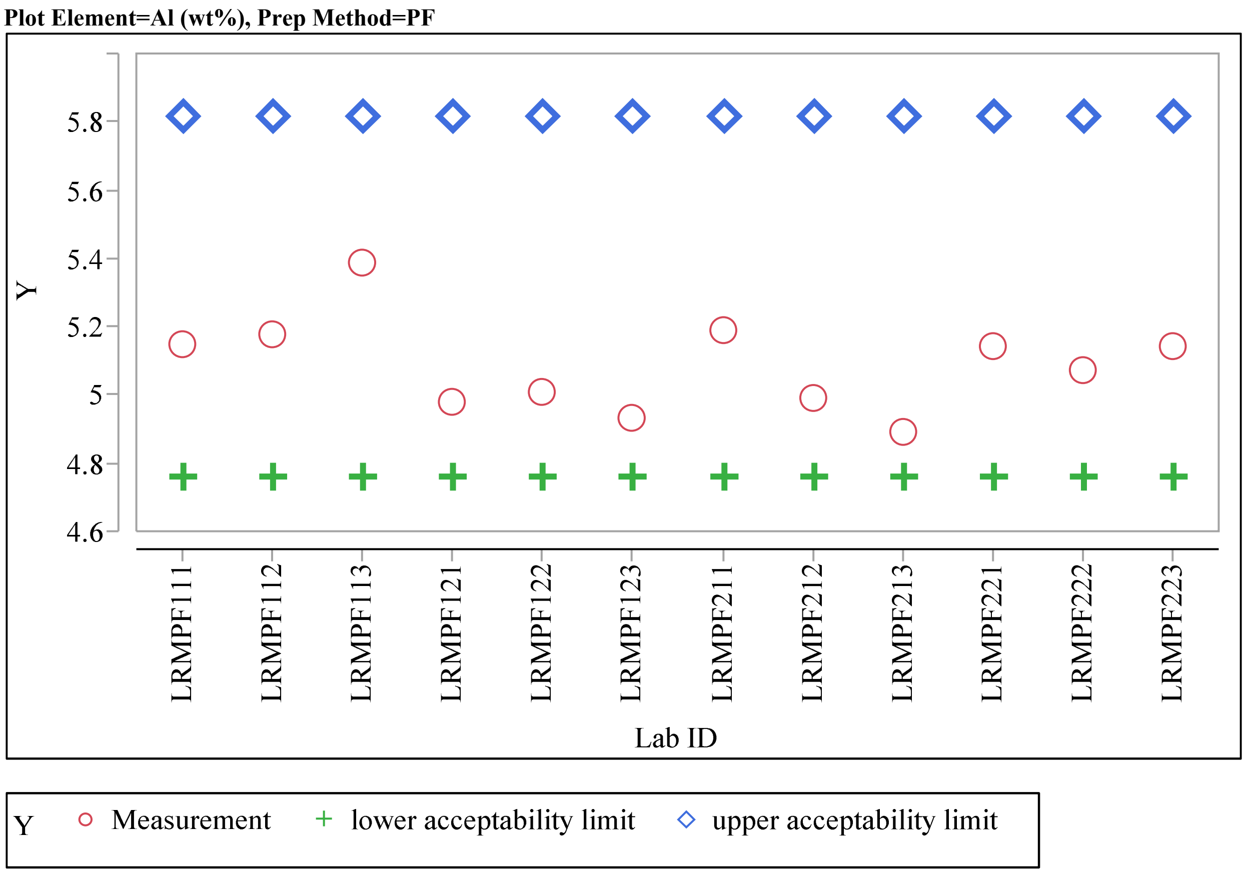


Exhibit A-3. Acceptability Evaluation for Measurements of the LRM Standard Glass (continued)

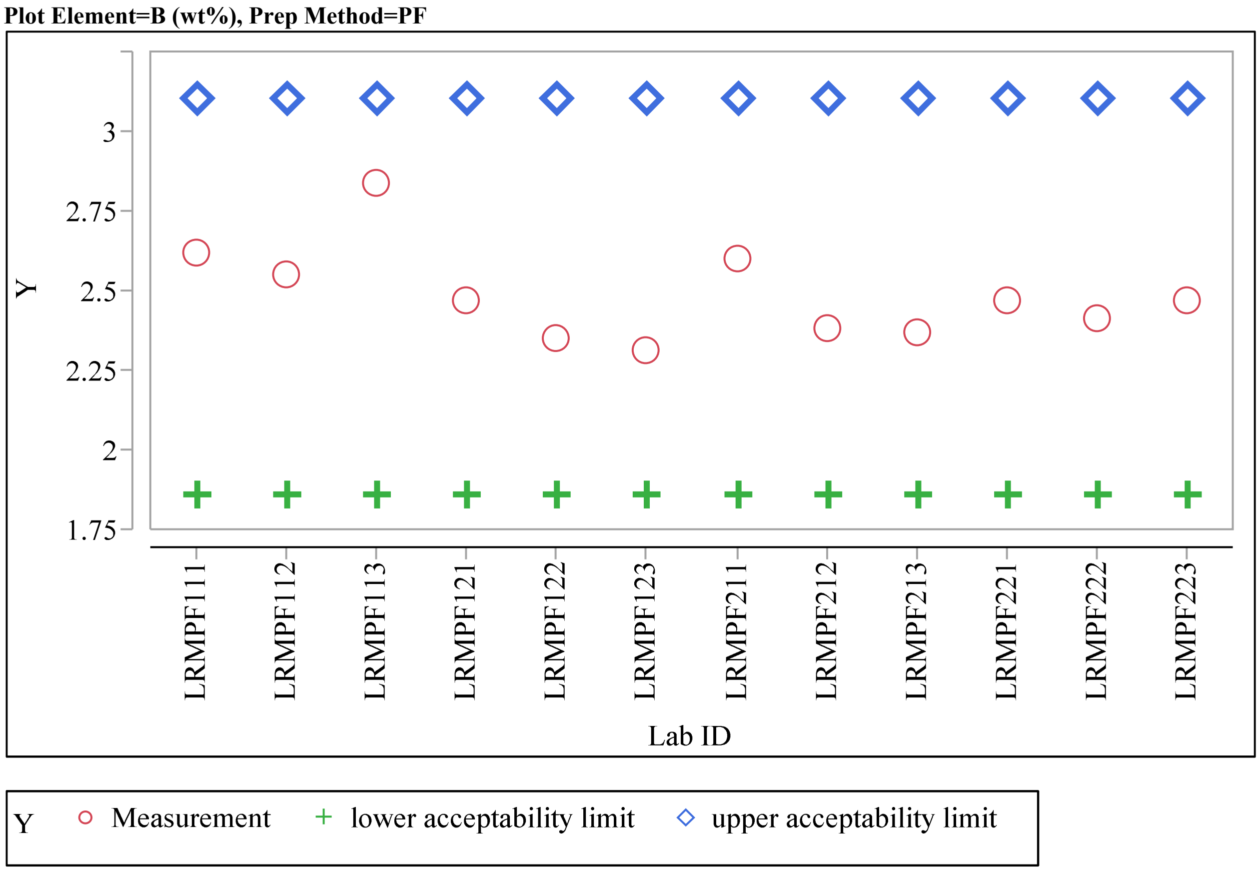


Exhibit A-3. Acceptability Evaluation for Measurements of the LRM Standard Glass (continued)

Plot Element=Fe (wt%), Prep Method=PF

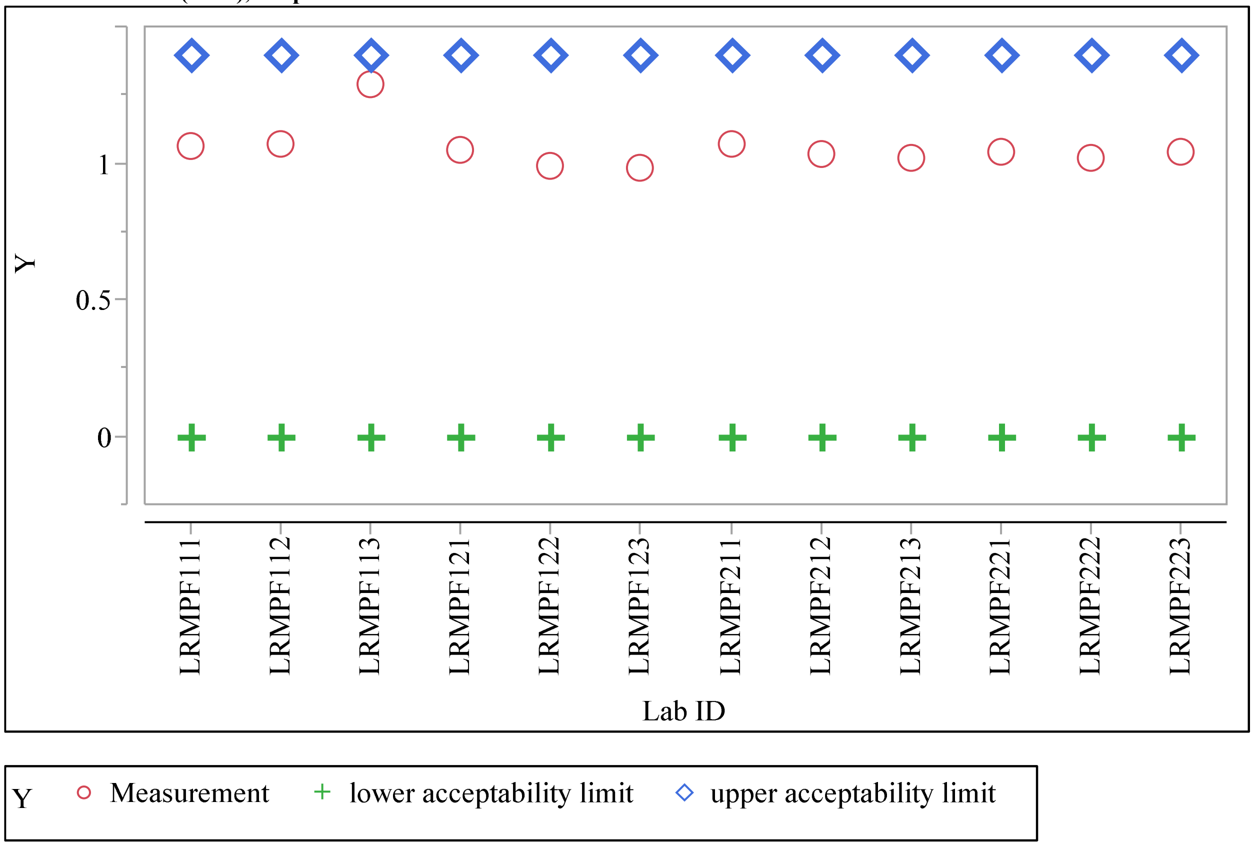


Exhibit A-3. Acceptability Evaluation for Measurements of the LRM Standard Glass (continued)

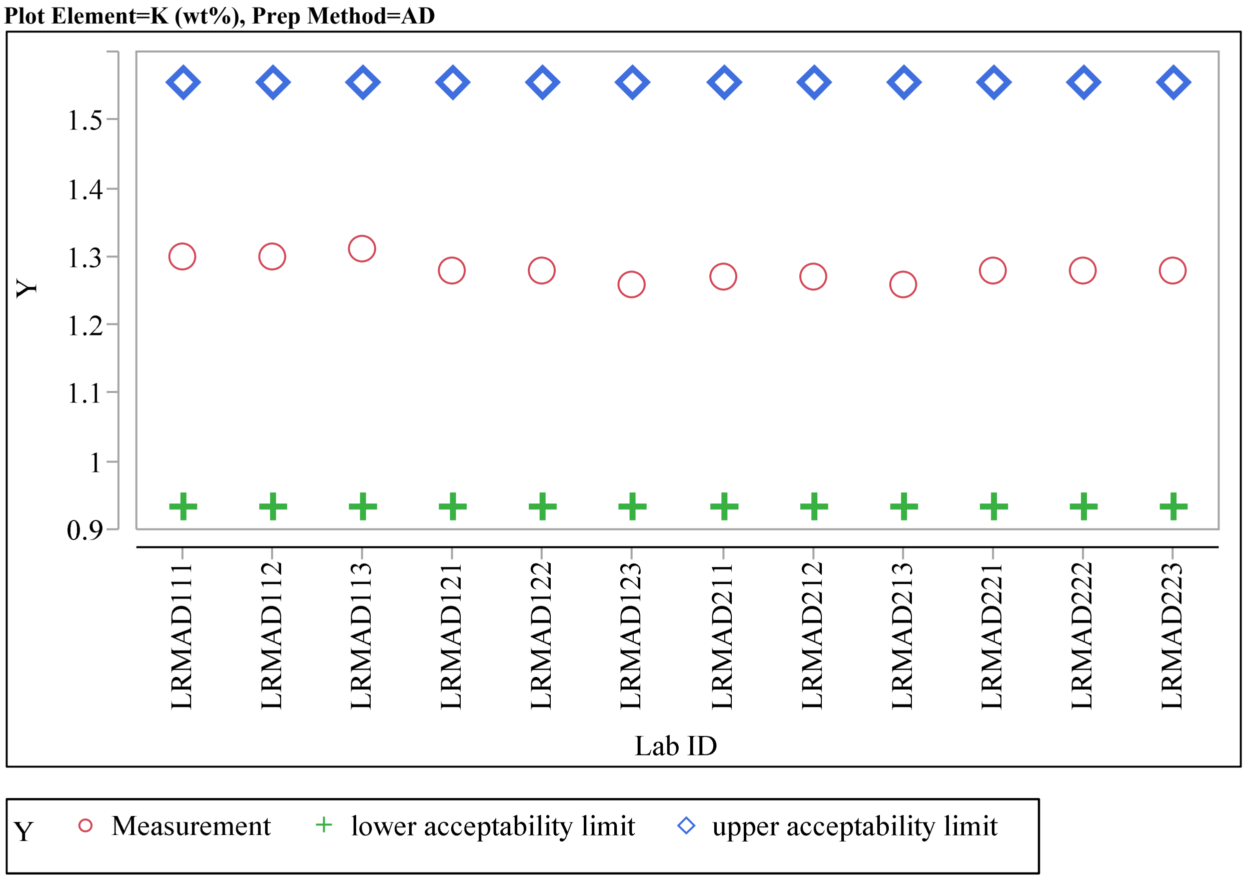


Exhibit A-3. Acceptability Evaluation for Measurements of the LRM Standard Glass (continued)

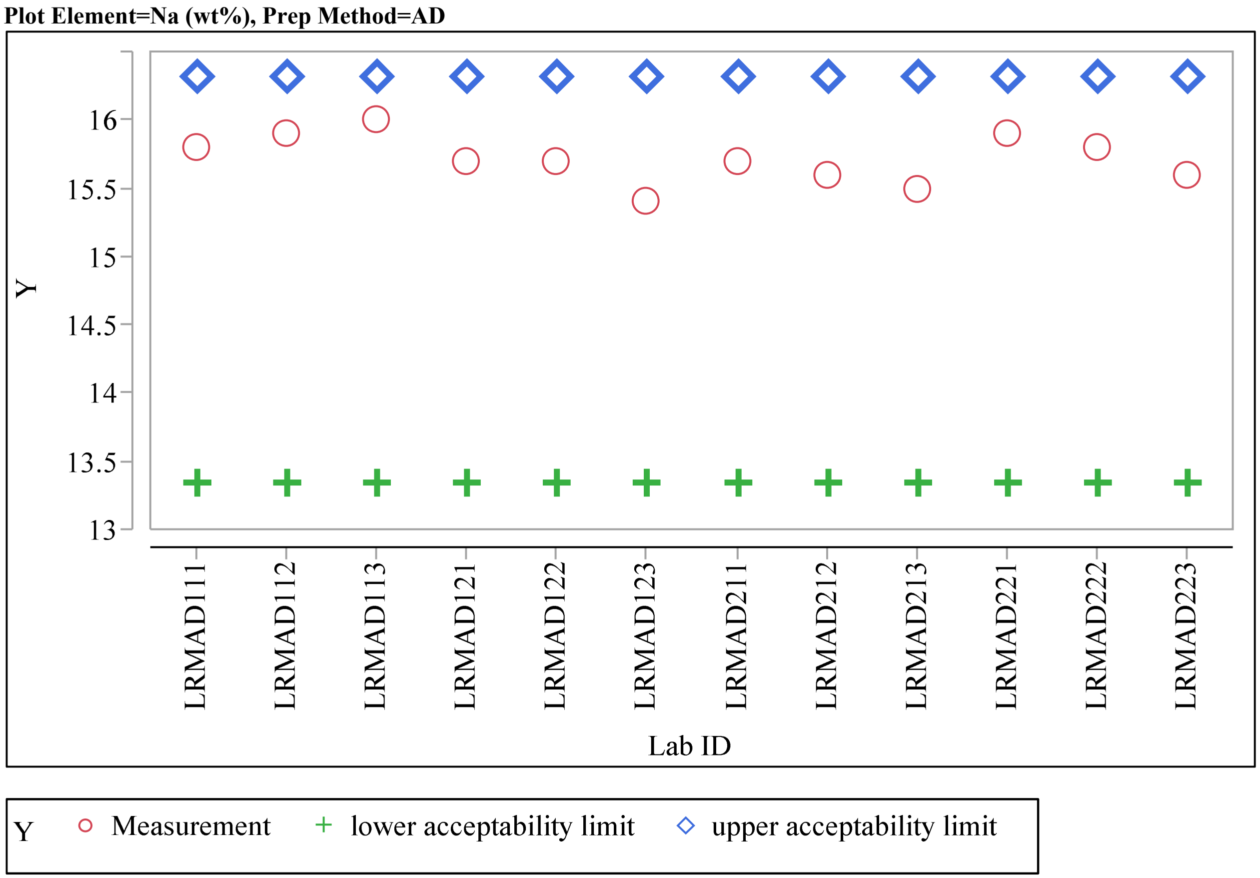


Exhibit A-3. Acceptability Evaluation for Measurements of the LRM Standard Glass (continued)

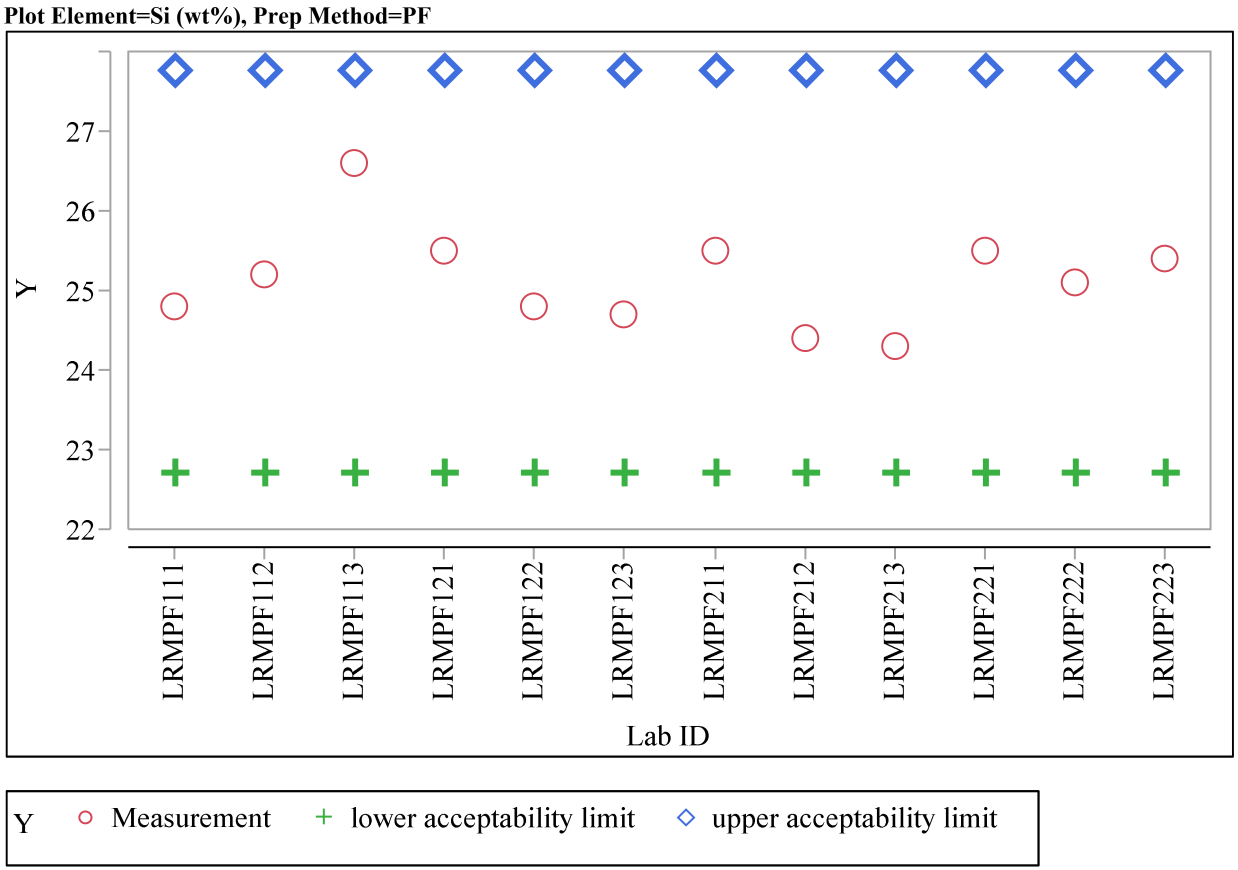


Exhibit A-3. Acceptability Evaluation for Measurements of the LRM Standard Glass (continued)

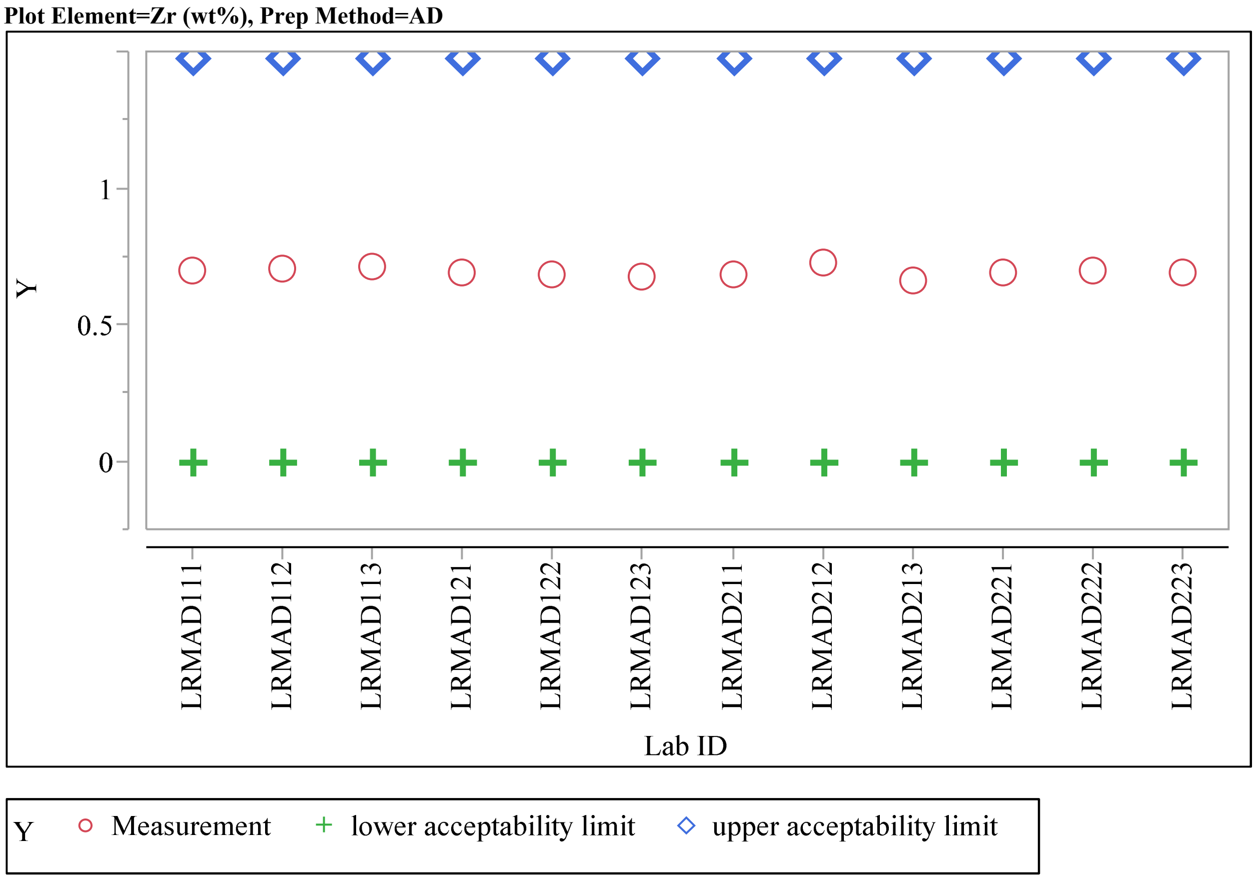


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide

Overlay Plot Analyte=Al2O3 (wt%)

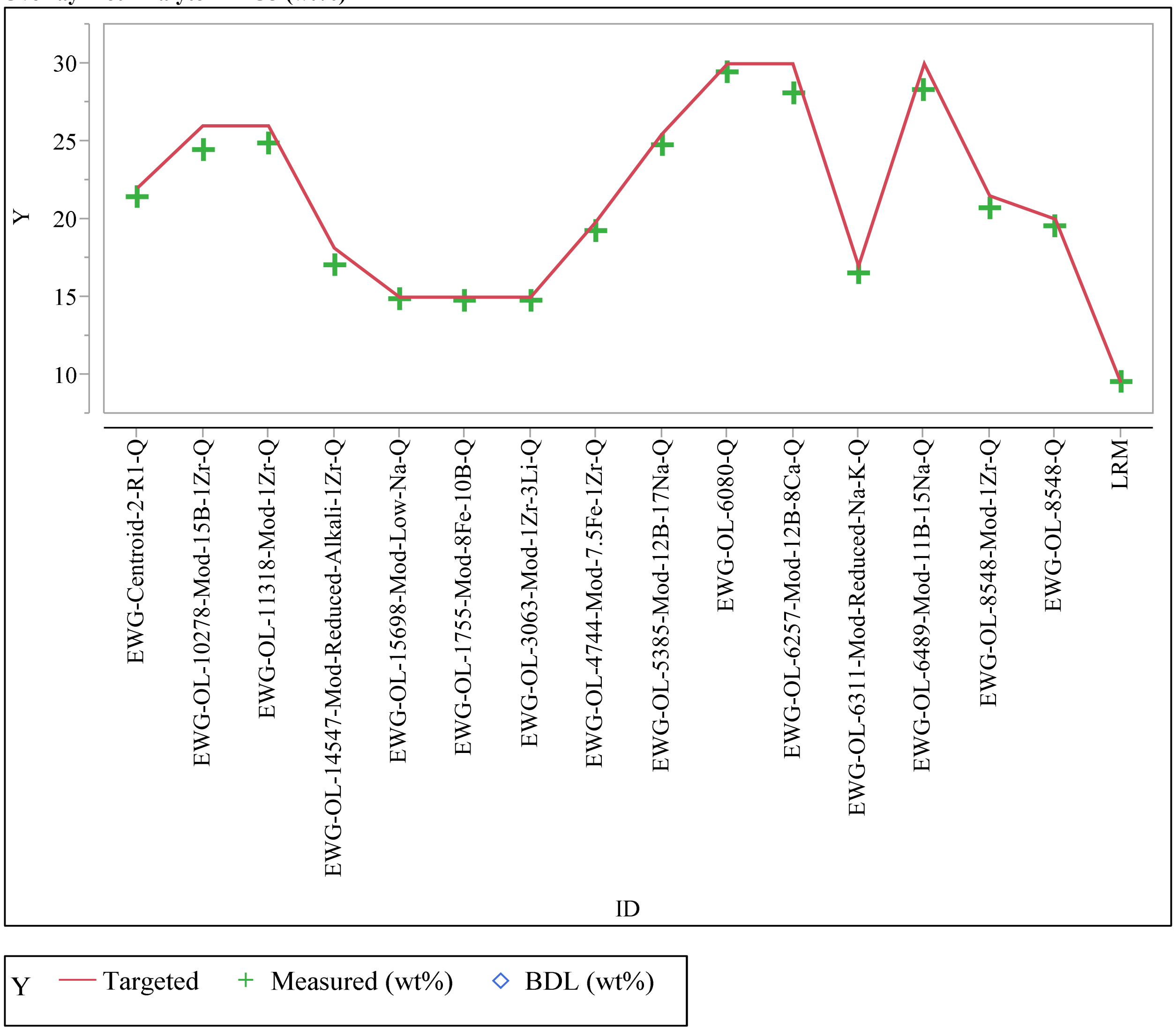


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

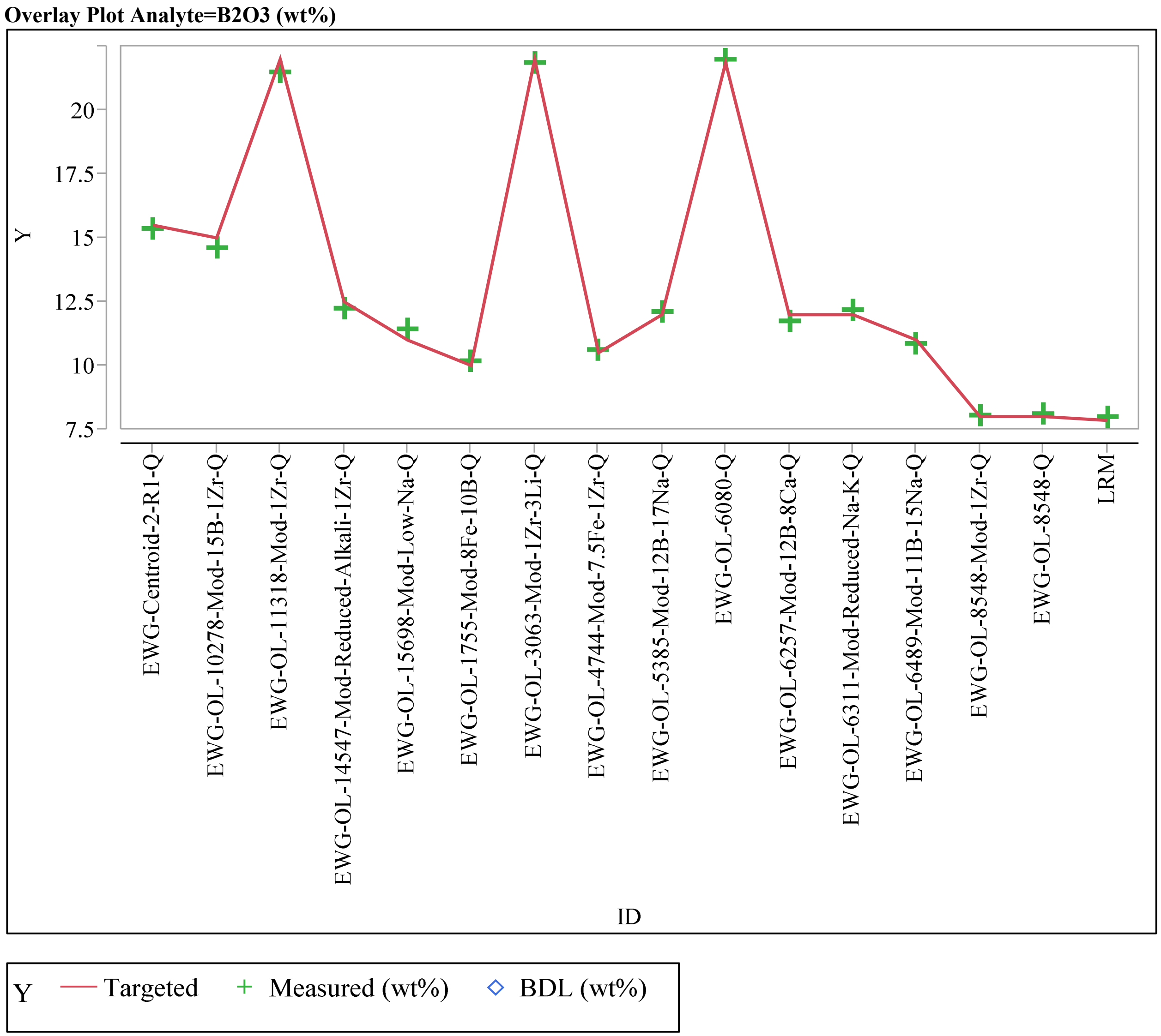


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

Overlay Plot Analyte=Bi2O3 (wt%)

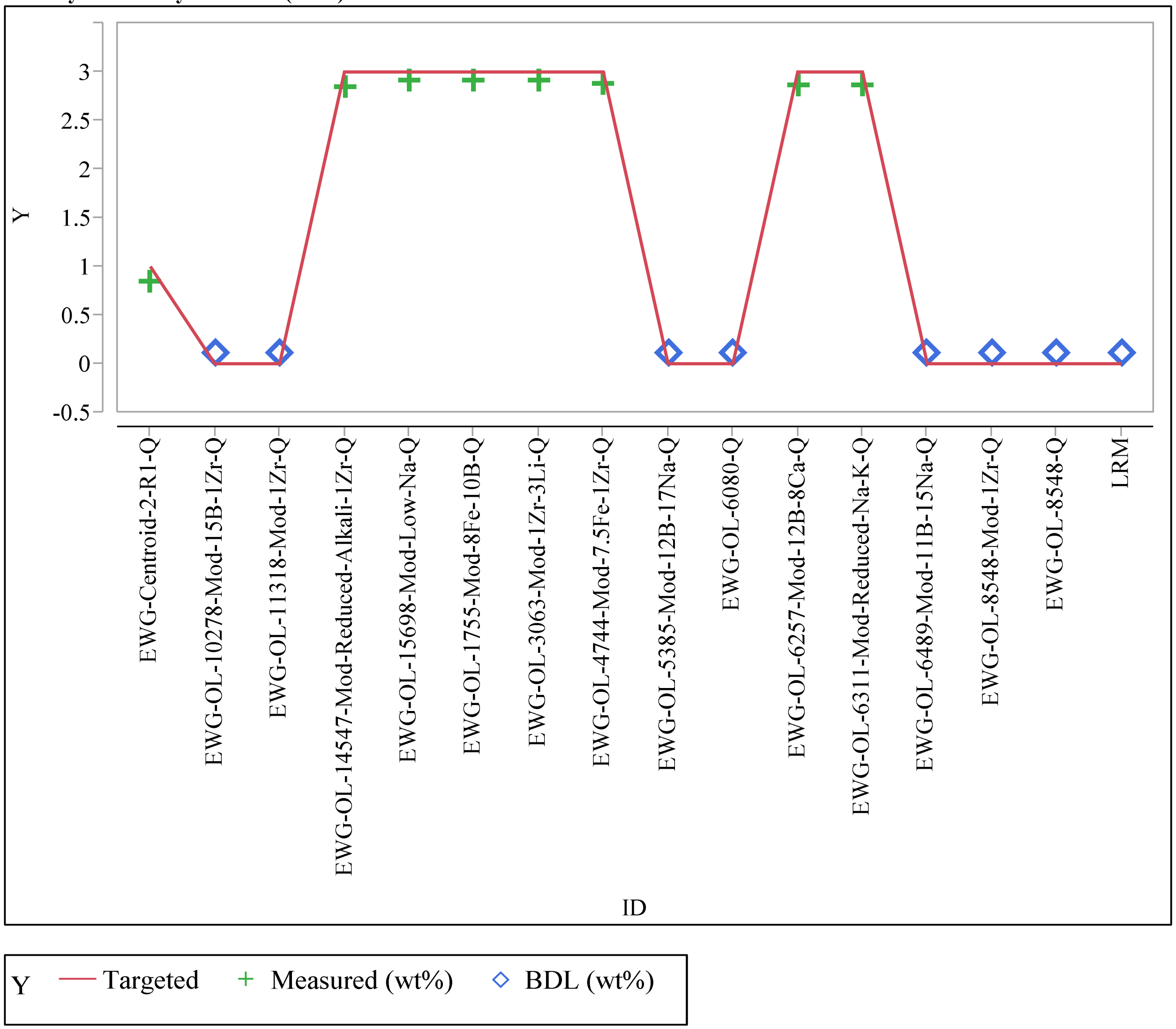


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

Overlay Plot Analyte=CaO (wt%)

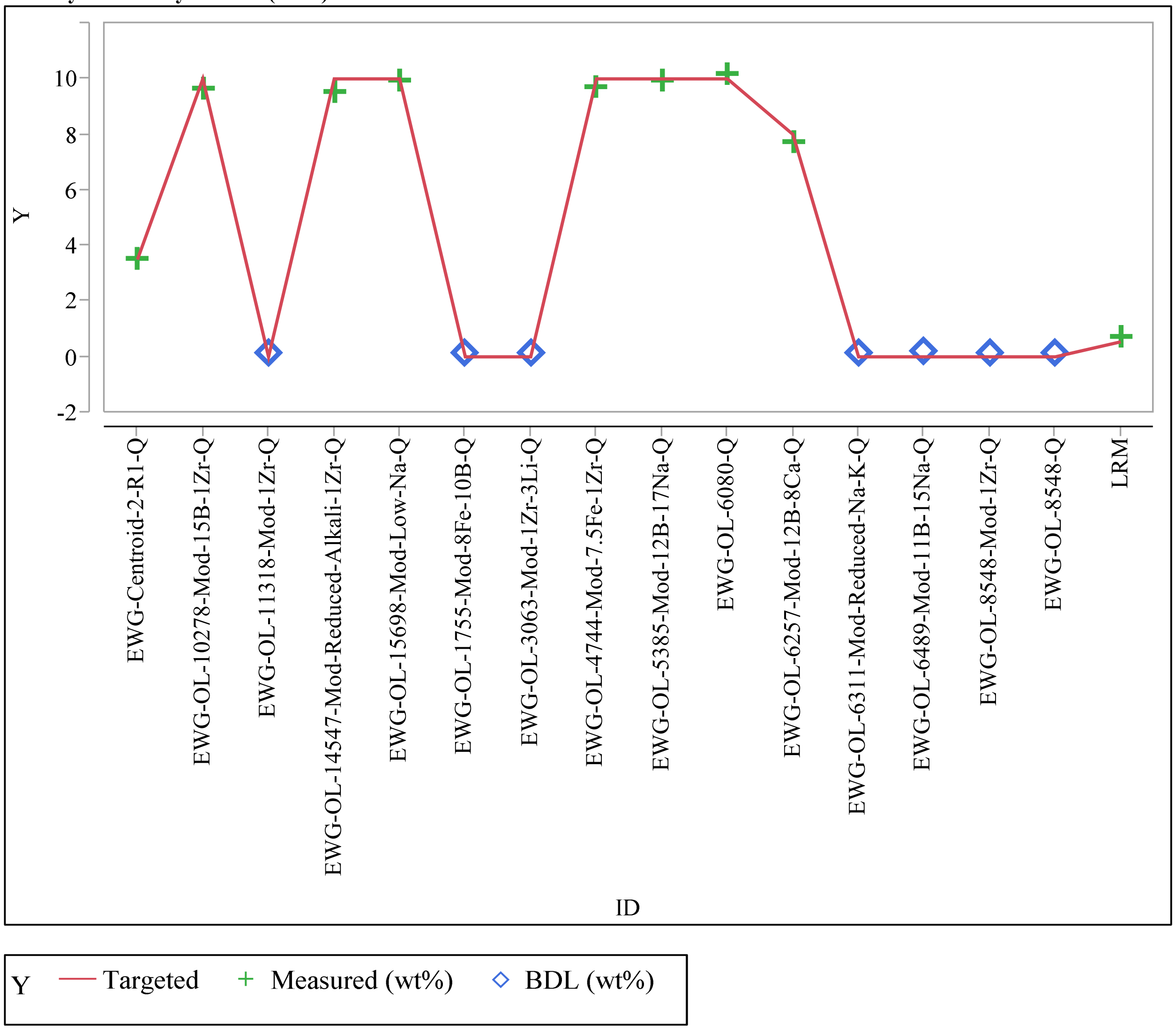


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

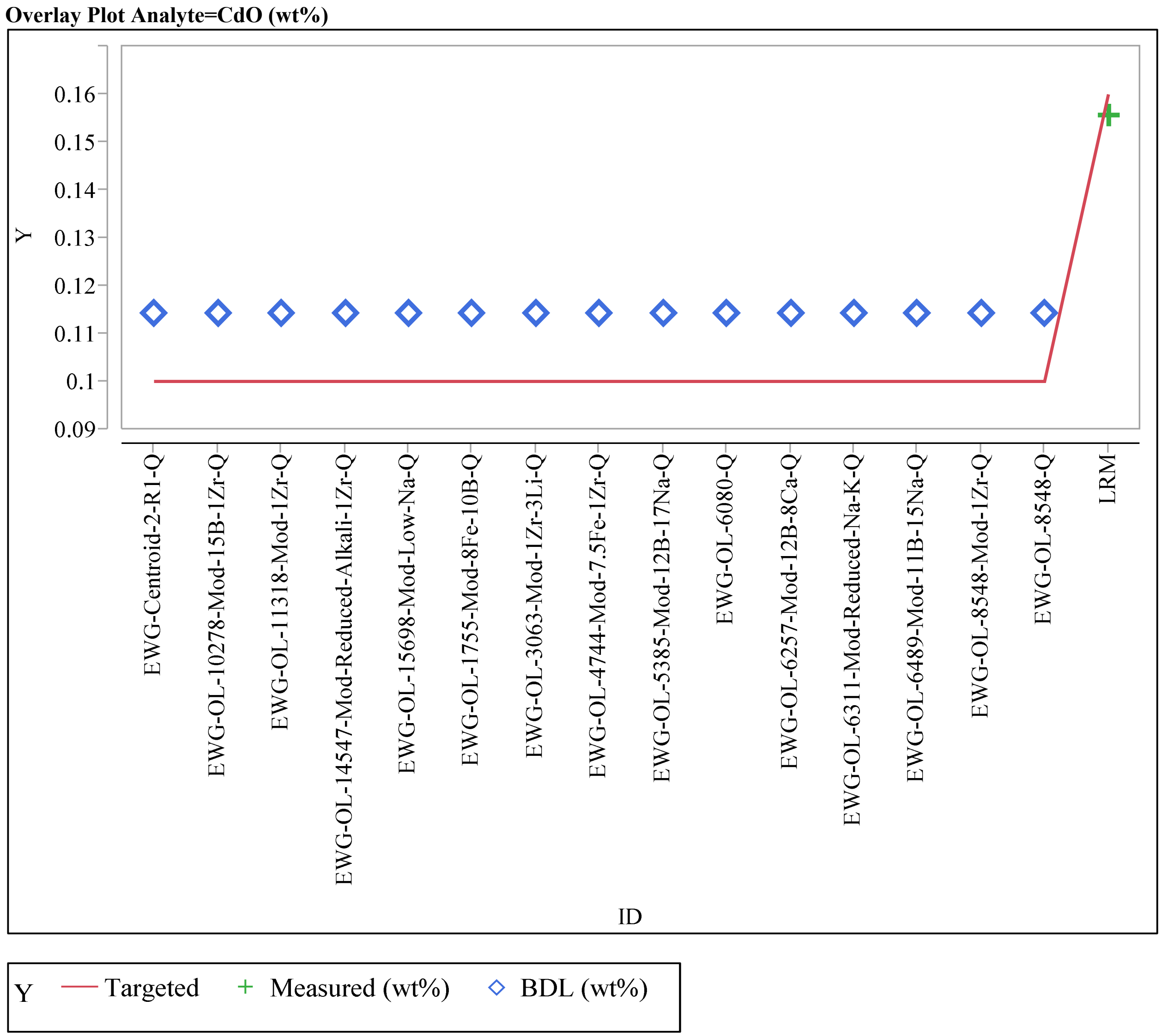


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

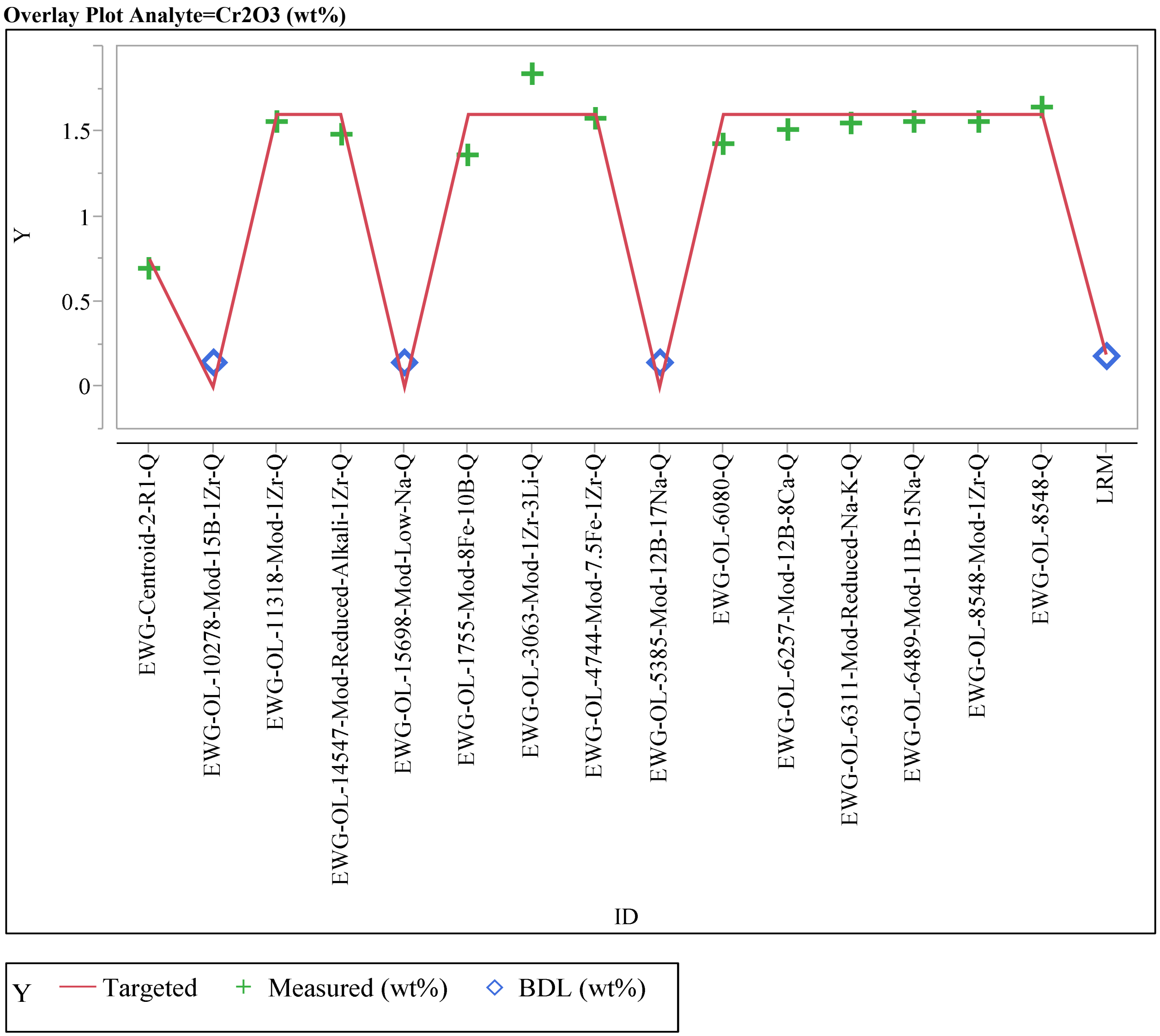


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

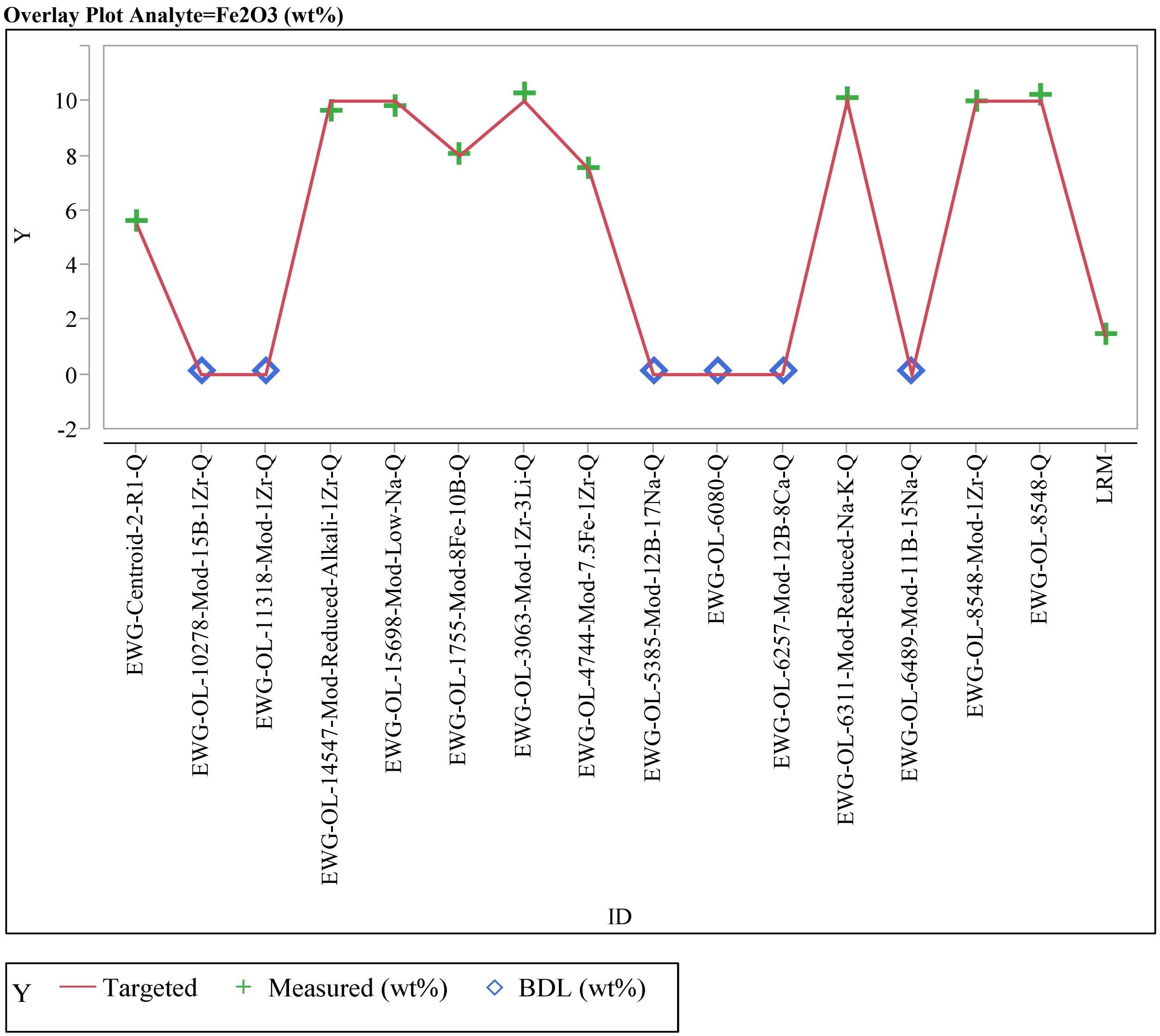


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

Overlay Plot Analyte=K2O (wt%)

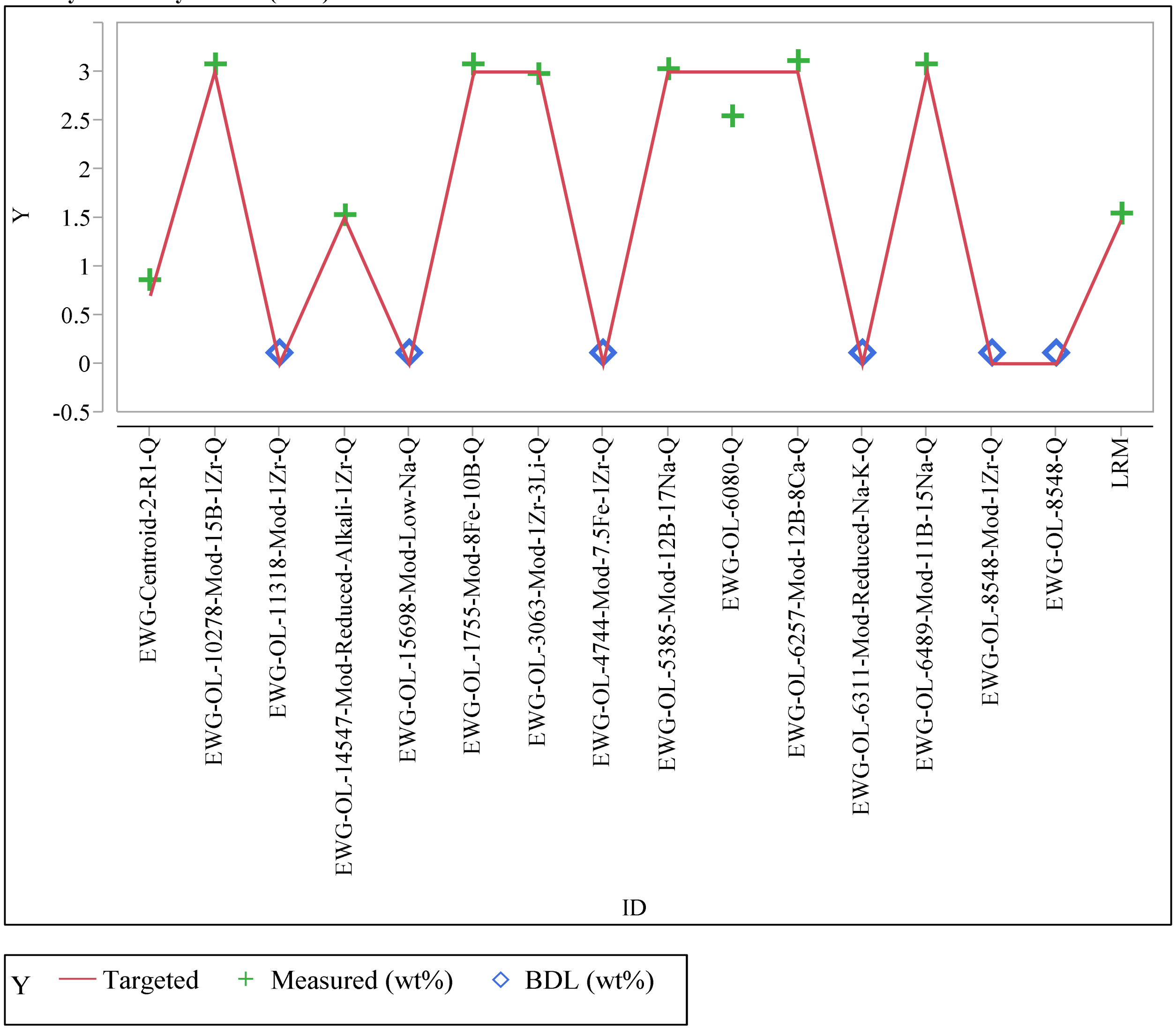


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

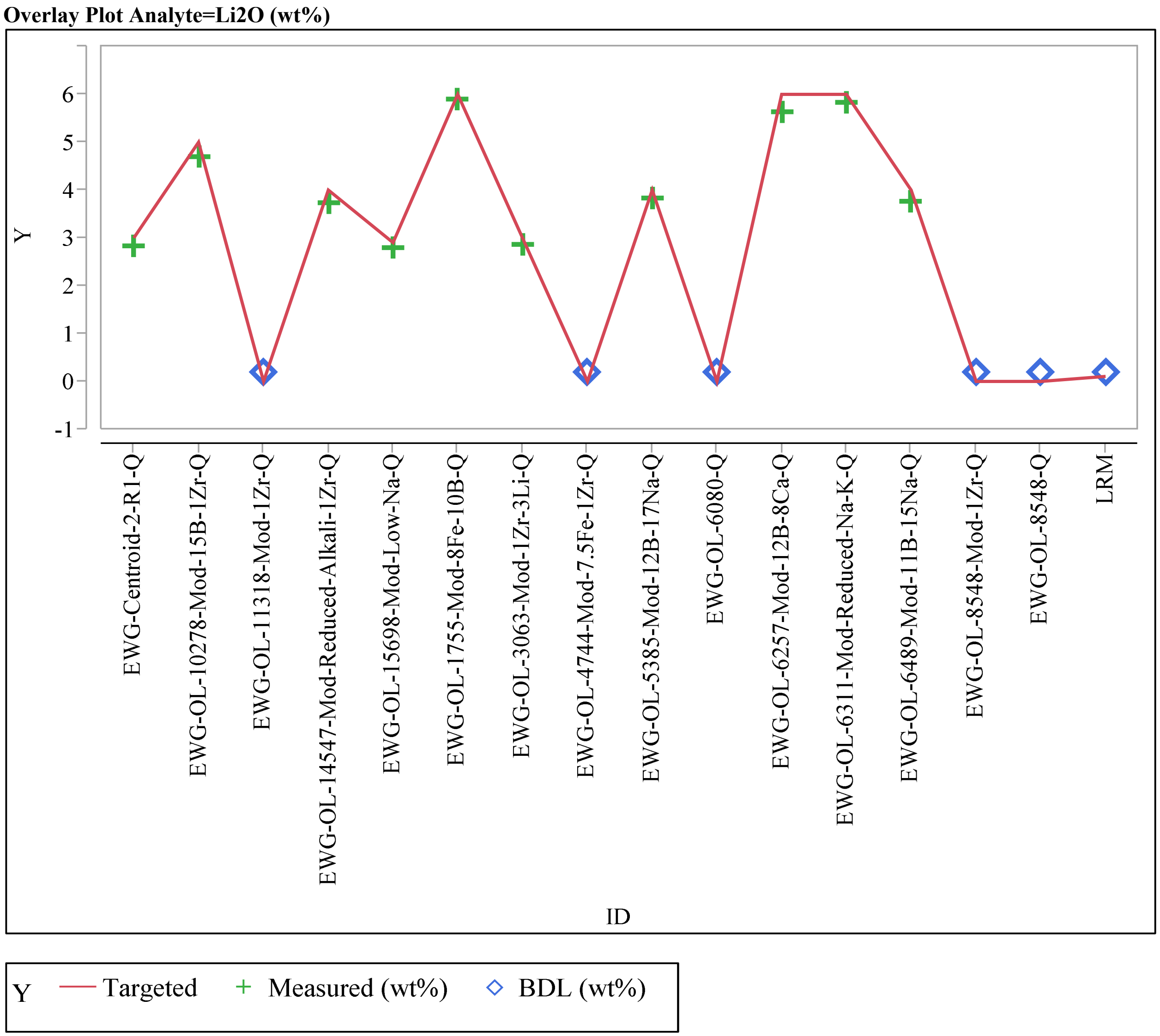


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

Overlay Plot Analyte=MgO (wt%)

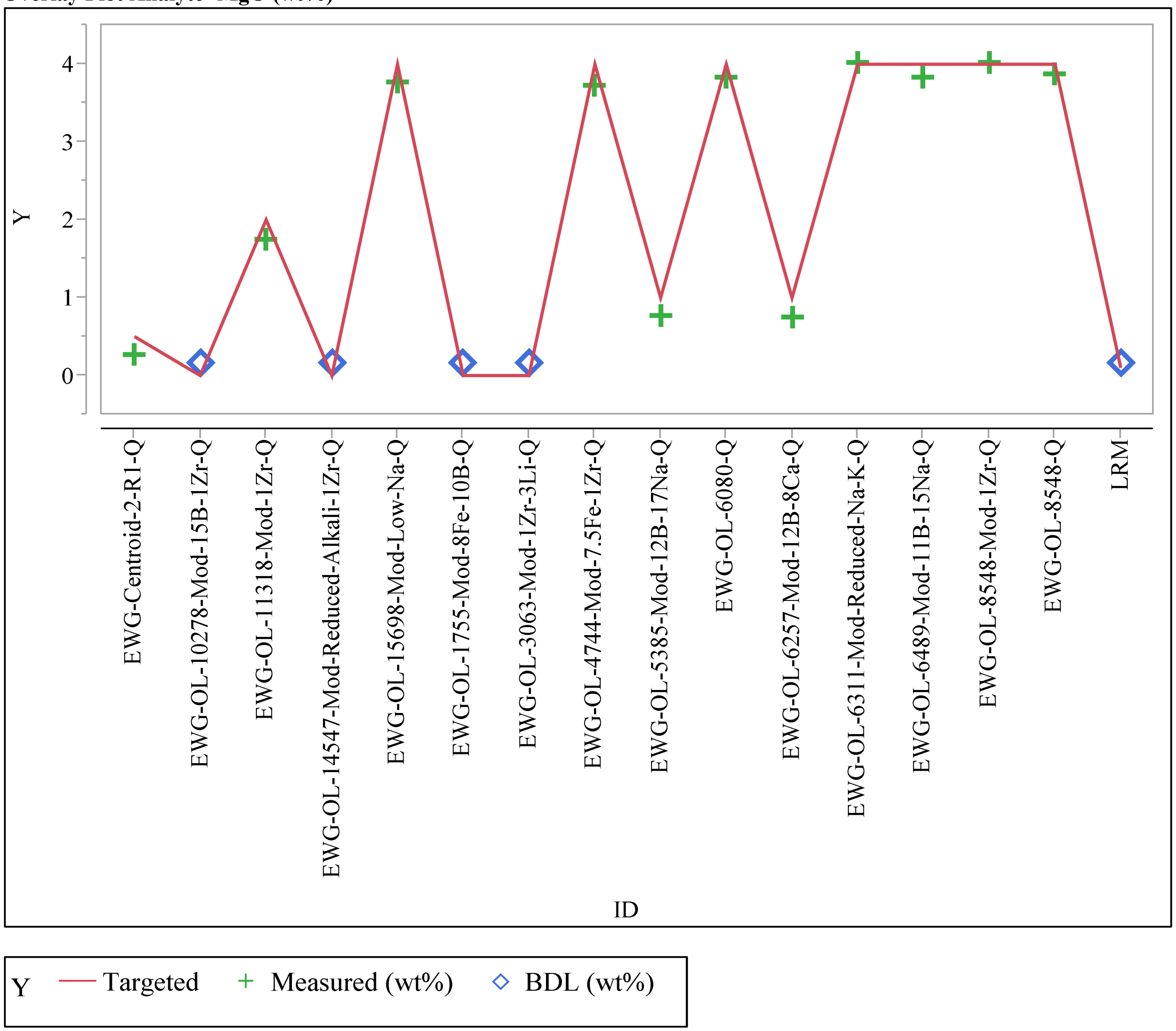


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

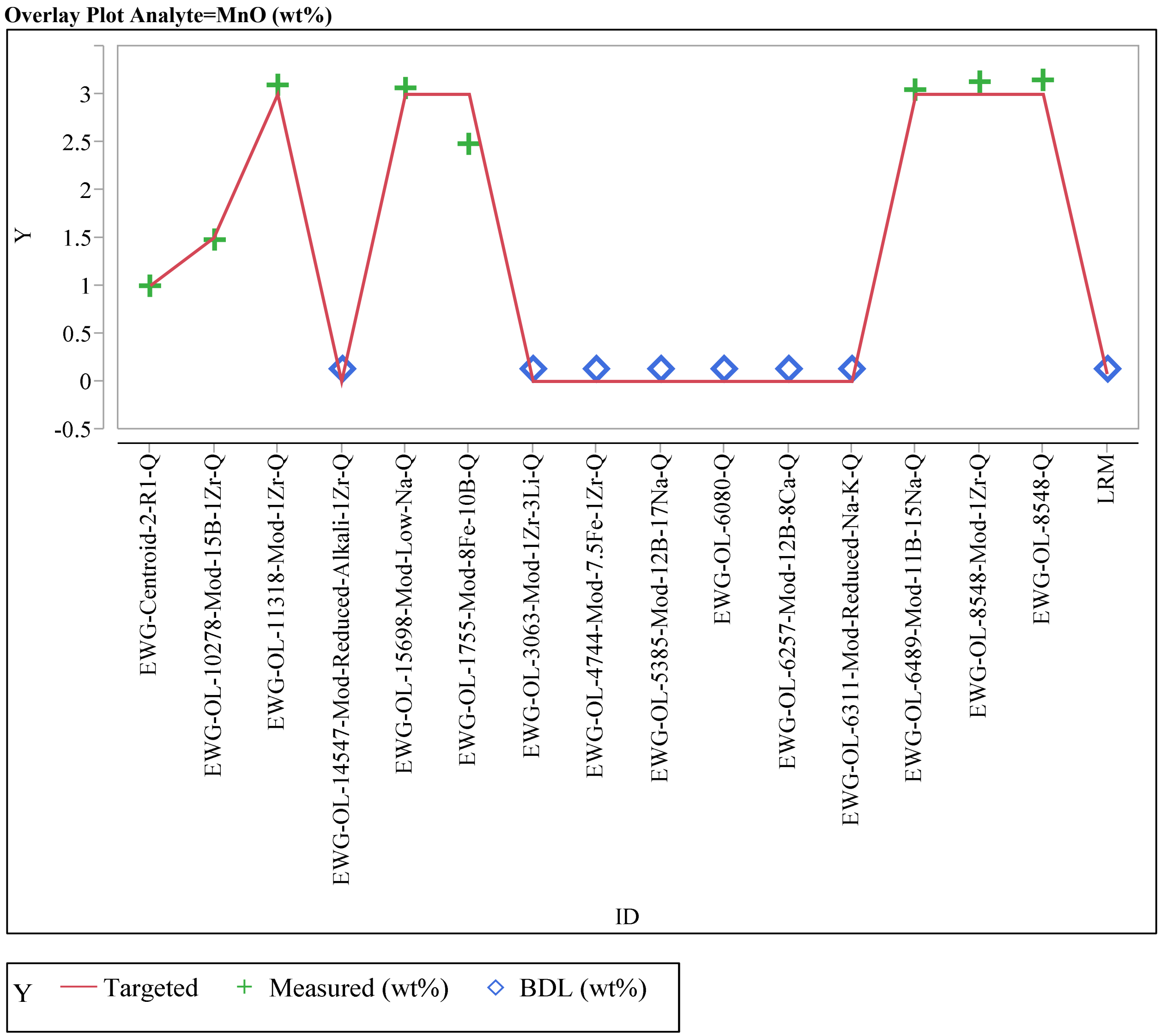


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

Overlay Plot Analyte=Na2O (wt%)

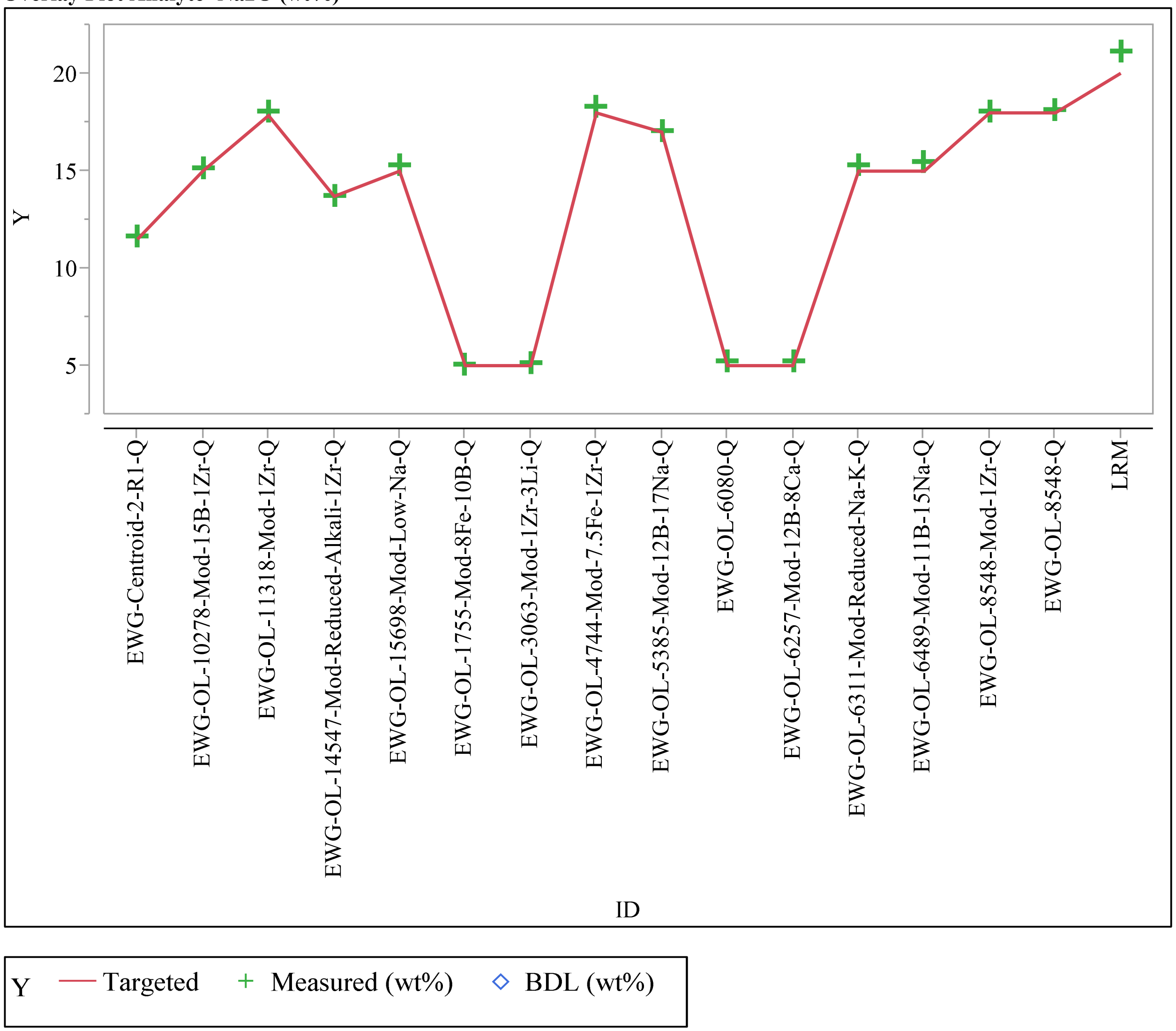


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

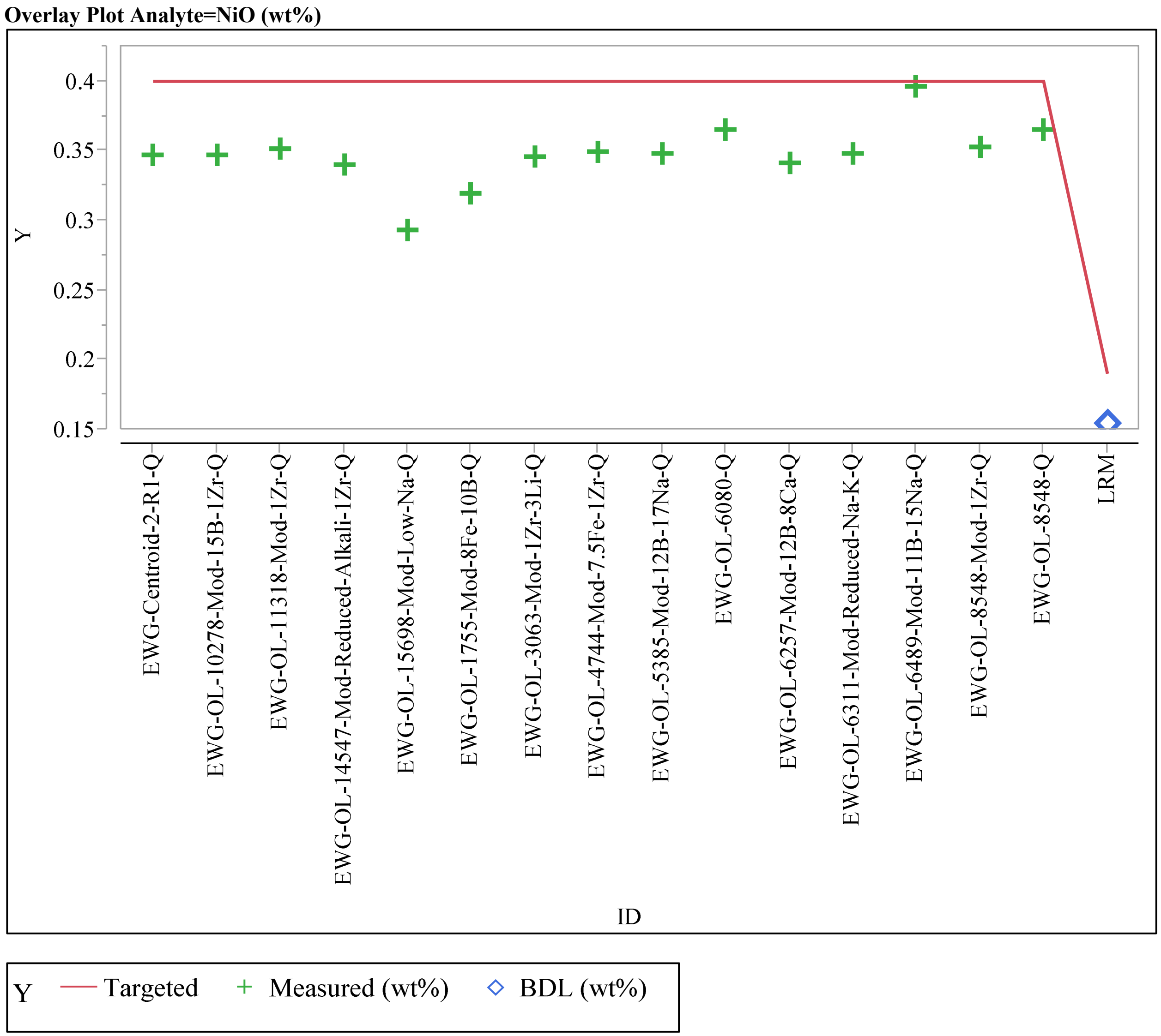


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

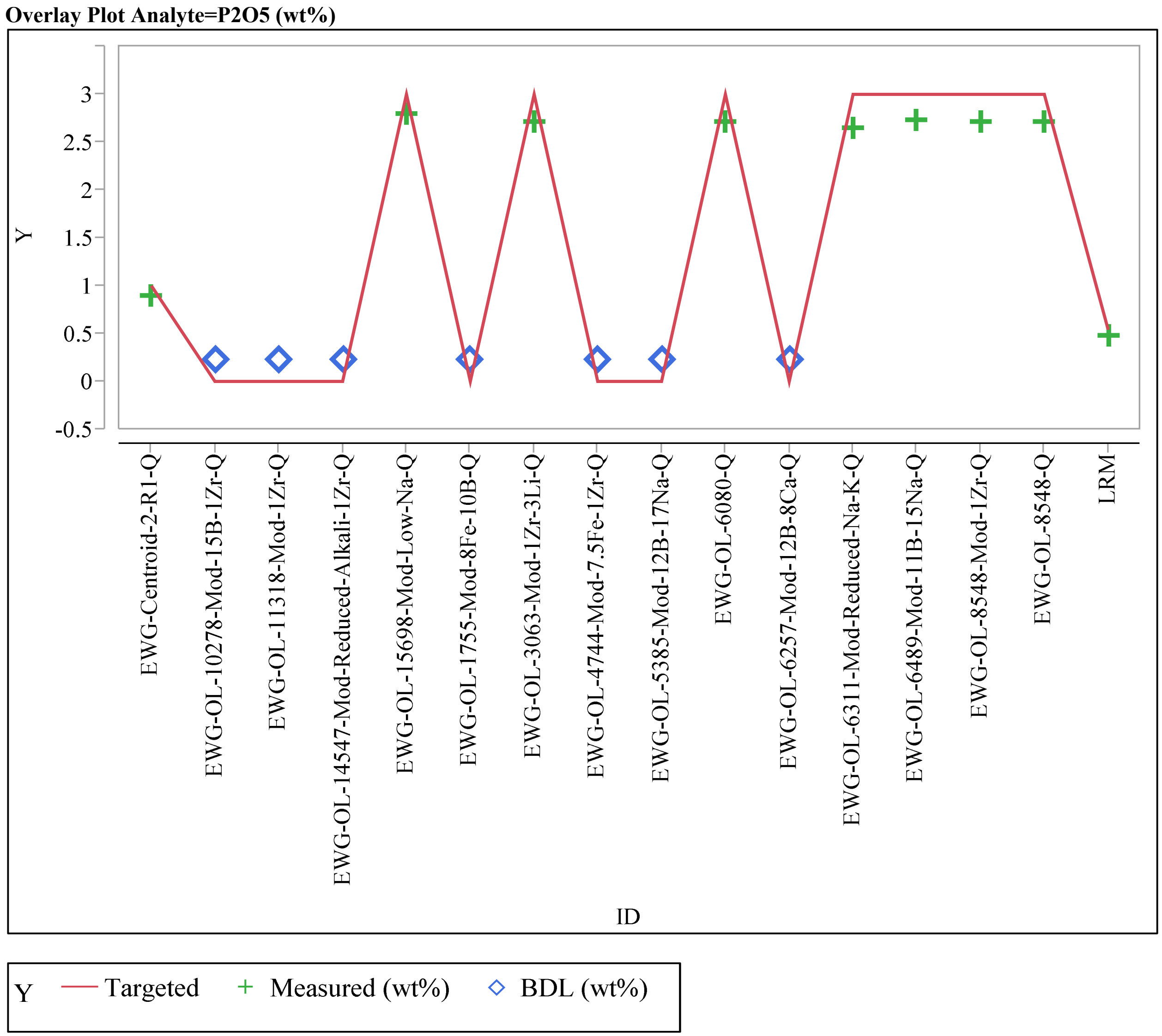


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

Overlay Plot Analyte=PbO (wt%)

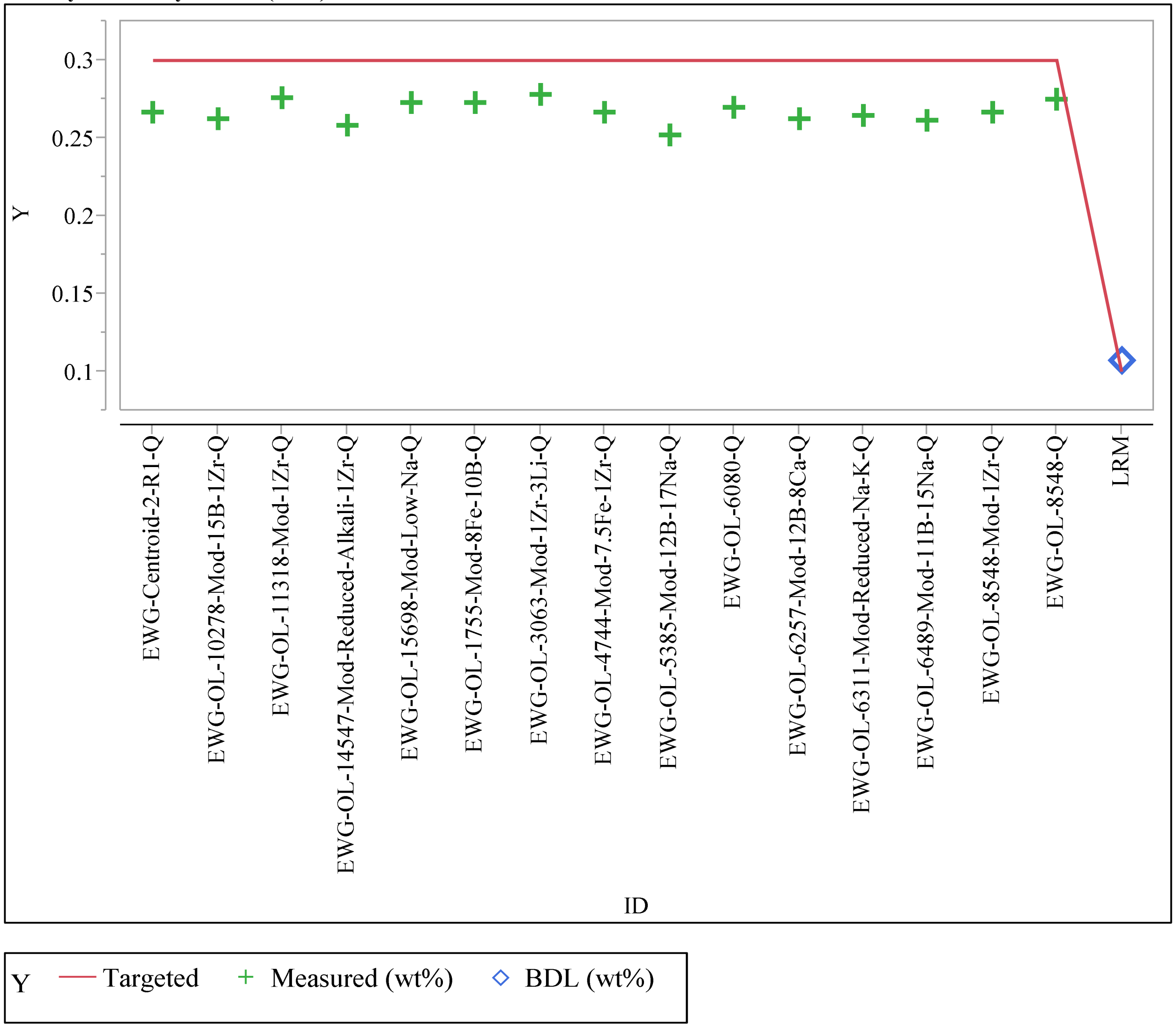


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

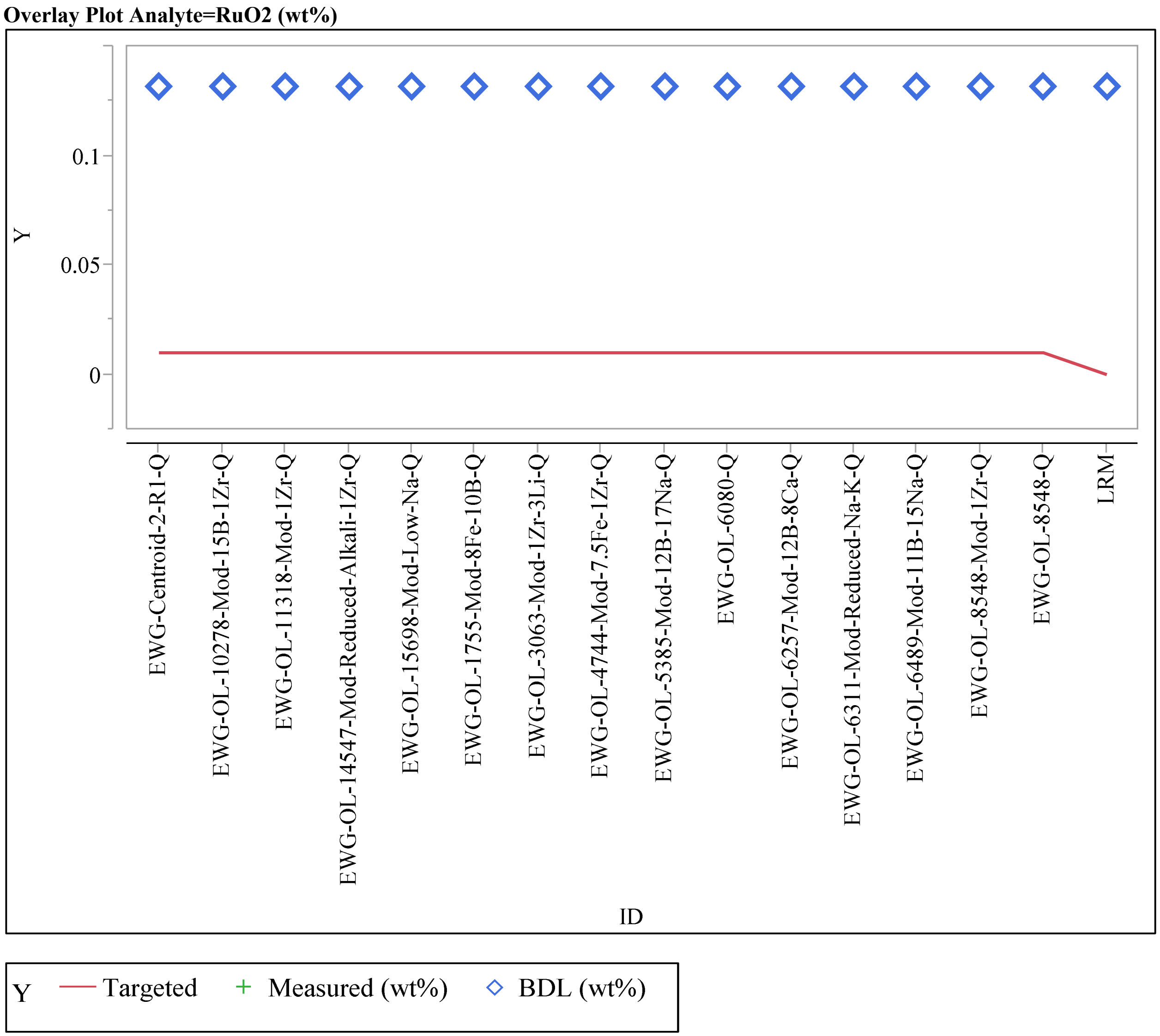


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

Overlay Plot Analyte=SiO2 (wt%)

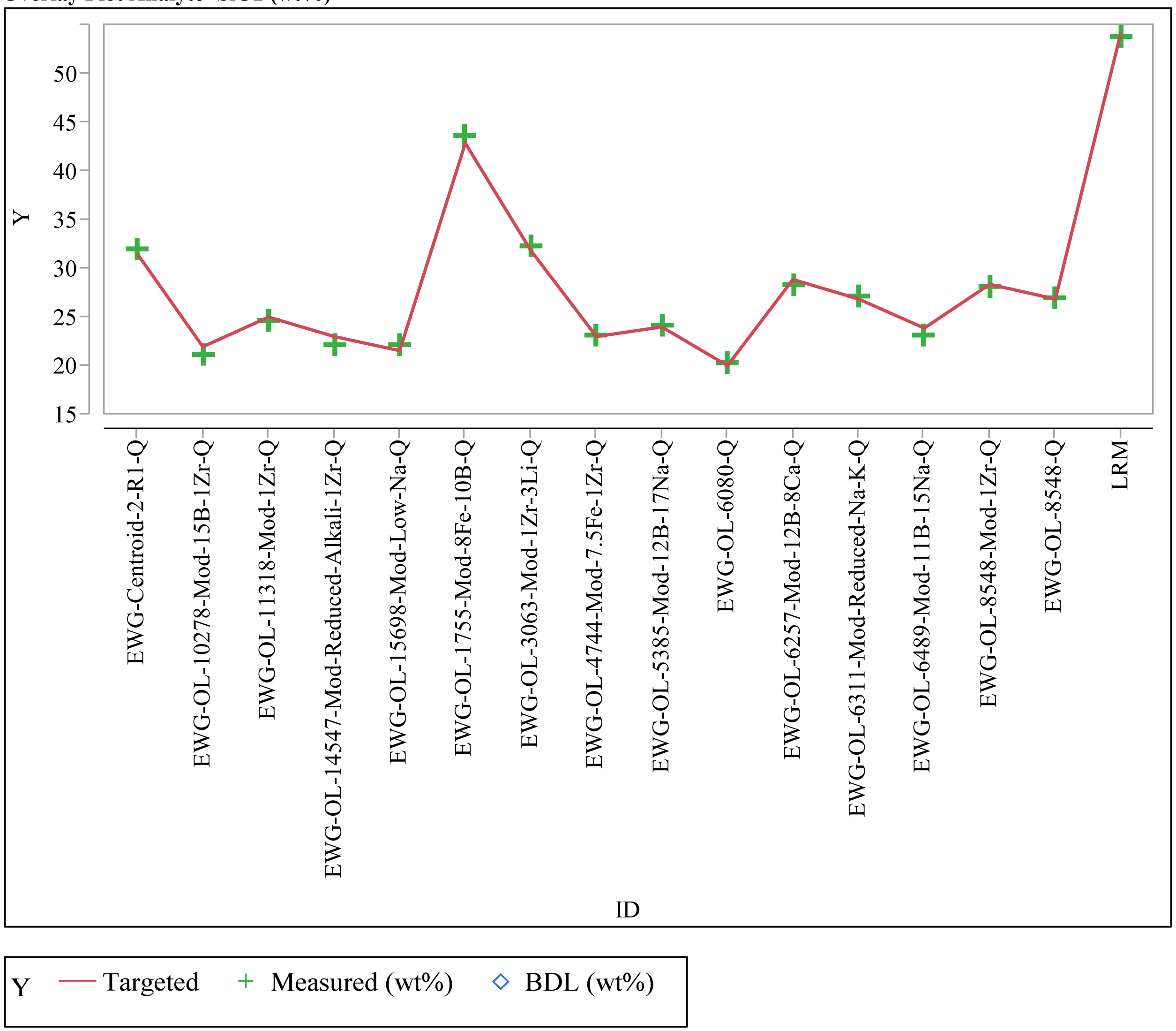


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

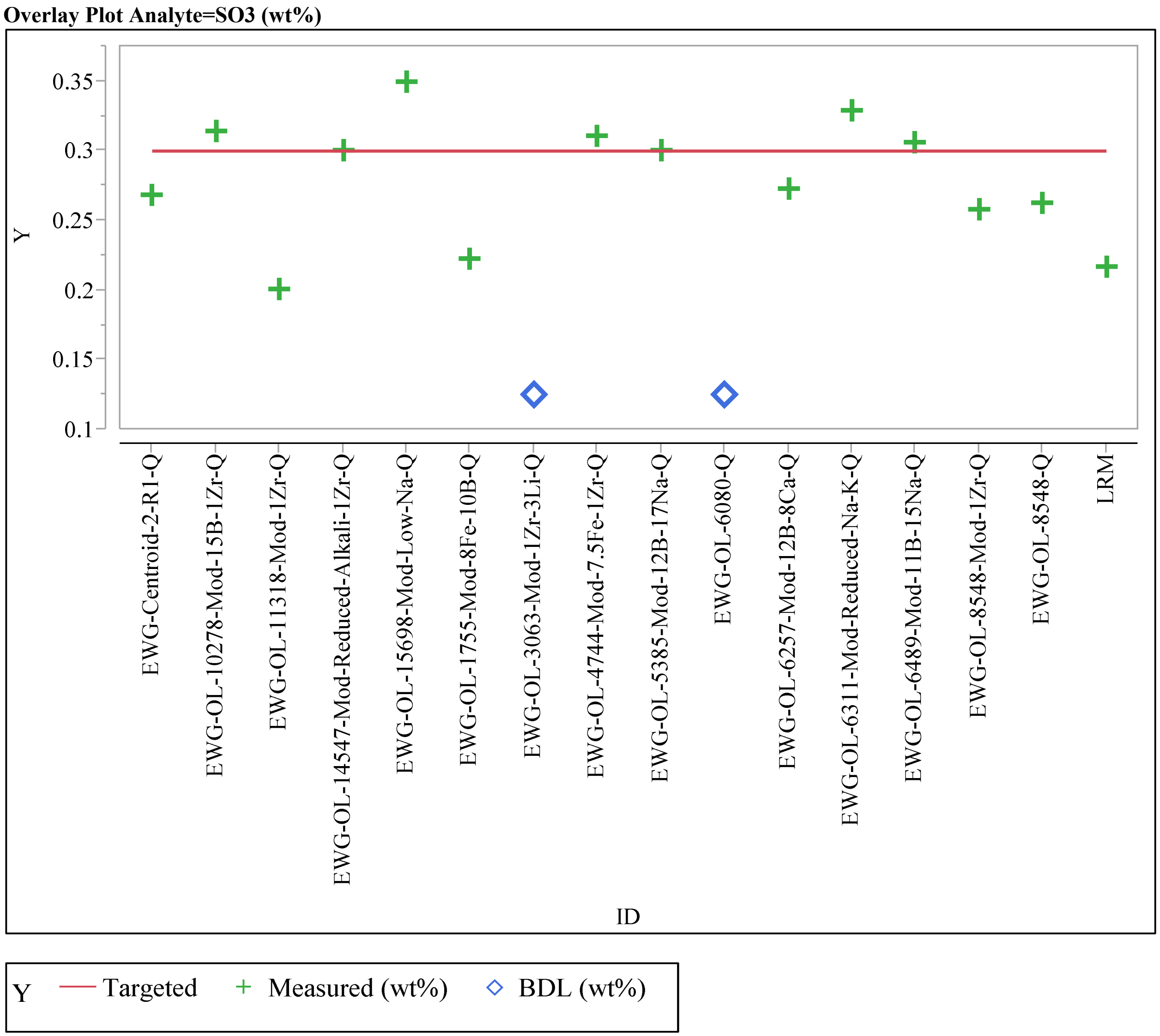


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

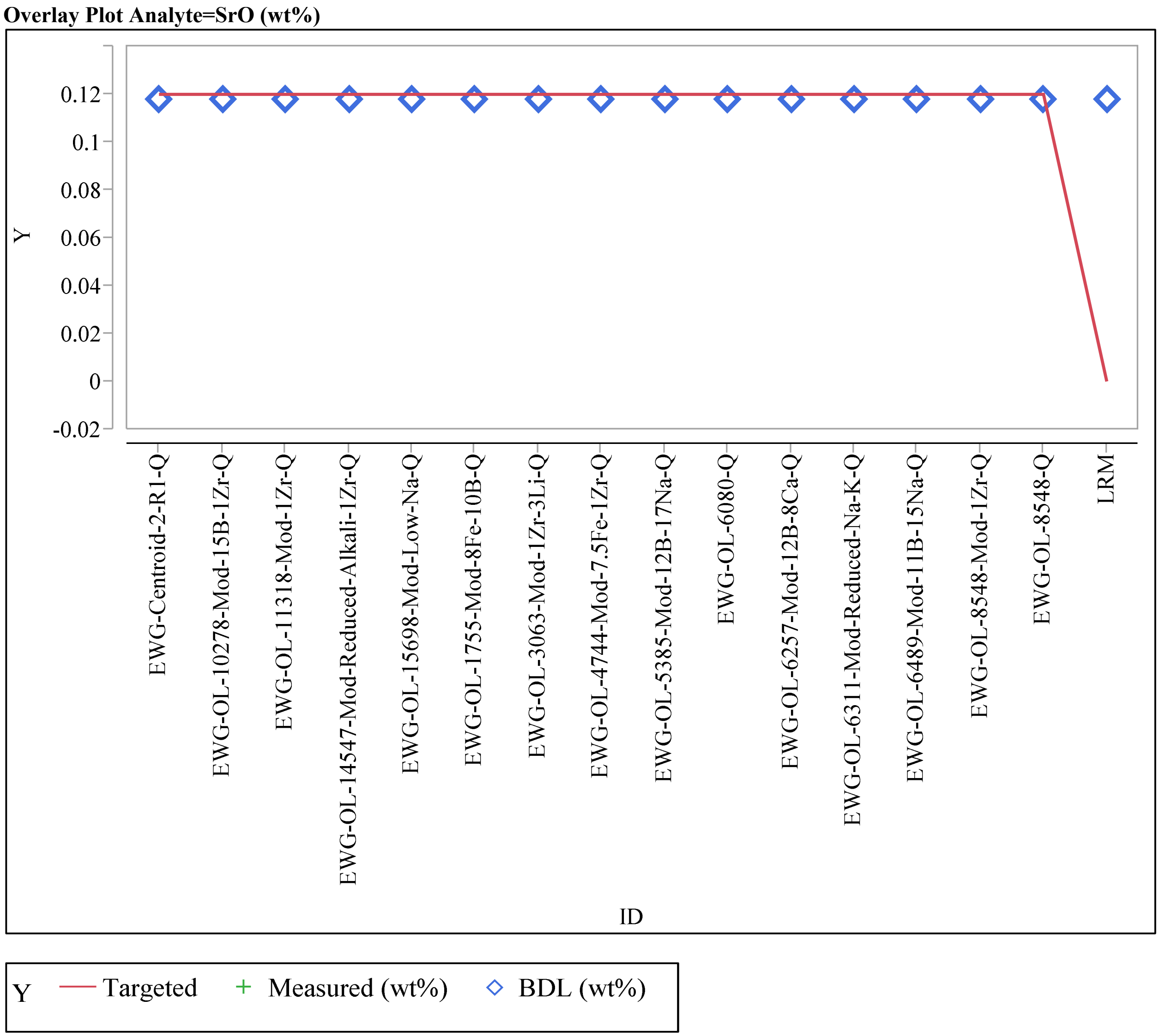


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

Overlay Plot Analyte=ZrO2 (wt%)

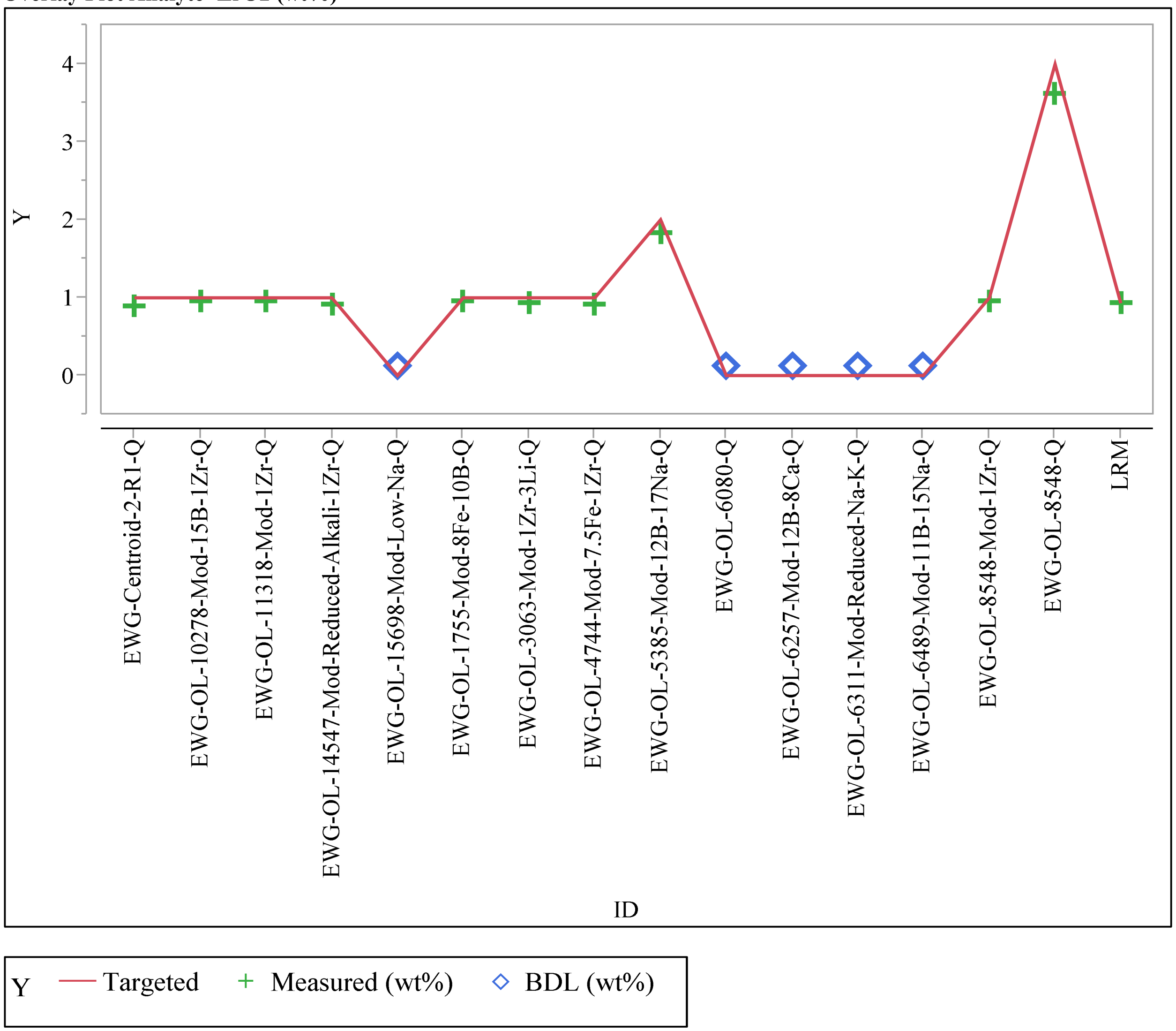
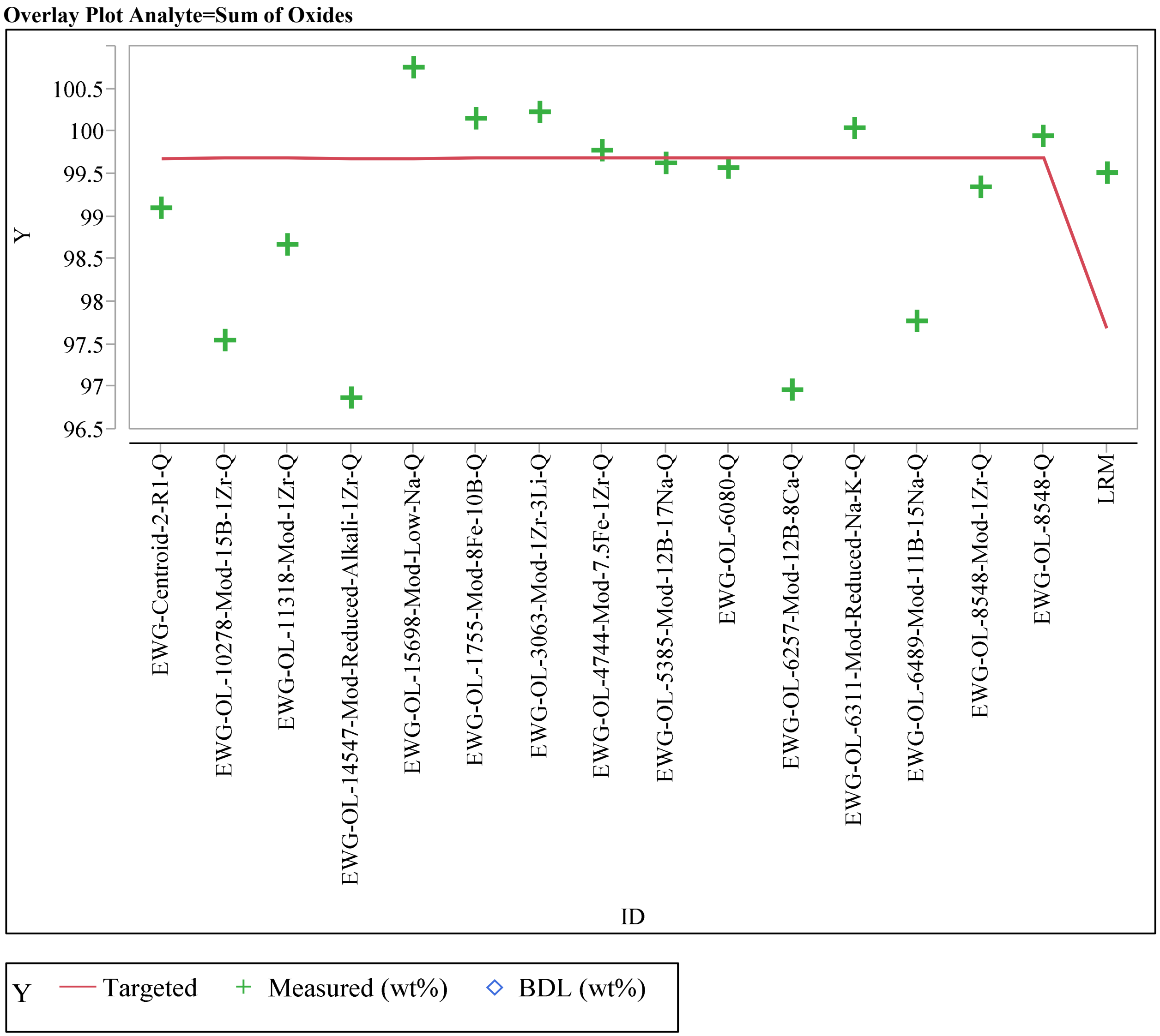


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)



Appendix B Tables and Exhibits Supporting the PCT Results

Table B-1. PCT Measurements for HLW Set 3 Study Glasses (ar – as received)

Set	Glass ID (w HT)	Block	Seq	Lab ID	B ar	Ca ar	K ar	Li ar	Na ar	P ar	Si ar	B (ppm)	Ca (ppm)	K (ppm)	Li (ppm)	Na (ppm)	P (ppm)	Si (ppm)
1	soln std	1	1	std-s1-1	20.0	<1.00	10.3	9.93	80.9	<1.00	48.4	20.000	1.000	10.300	9.930	80.900	1.000	48.400
1	EWG-OL-5385-Mod-12B-17Na-Q	1	2	S34	44.4	2.29	27.2	26.3	198	<1.00	17.9	74.001	3.817	45.334	43.834	330.007	1.667	29.834
1	EWG-OL-3063-Mod-1Zr-3Li-CCC	1	3	S28	594	<1.00	10.3	79.4	92.2	2.76	21.1	990.020	1.667	17.167	132.336	153.670	4.600	35.167
1	EWG-OL-1755-Mod-8Fe-10B-Q	1	4	S35	9.25	<1.00	4.19	8.50	5.86	<1.00	37.6	15.417	1.667	6.983	14.167	9.767	1.667	62.668
1	EWG-Centroid-2-R1-Q	1	5	S30	10.7	<1.00	1.38	4.20	18.7	1.08	15.7	17.834	1.667	2.300	7.000	31.167	1.800	26.167
1	EWG-OL-1755-Mod-8Fe-10B-CCC	1	6	S02	7.63	<1.00	4.19	8.12	6.42	<1.00	38.2	12.717	1.667	6.983	13.534	10.700	1.667	63.668
1	EWG-OL-5385-Mod-12B-17Na-CCC	1	7	S29	826	4.30	49.2	328	2090	<1.00	30.8	1376.694	7.167	82.002	546.678	3483.403	1.667	51.334
1	EWG-OL-6257-Mod-12B-8Ca-Q	1	8	S14	6.54	2.67	2.83	4.45	5.11	<1.00	5.98	10.900	4.450	4.717	7.417	8.517	1.667	9.967
1	blank	1	9	S25	1.67	<1.00	<1.00	<1.00	1.11	<1.00	<1.00	2.783	1.667	1.667	1.667	1.850	1.667	1.667
1	EWG-OL-6311-Mod-Reduced-Na-K-CCC	1	10	S01	1790	<1.00	<1.00	746	2040	<1.00	39.2	2983.393	1.667	1.667	1243.358	3400.068	1.667	65.335
1	soln std	1	11	std-s1-2	19.9	<1.00	10.7	10.2	83.6	<1.00	50.0	19.900	1.000	10.700	10.200	83.600	1.000	50.000
1	EWG-OL-6489-Mod-11B-15Na-CCC	1	12	S32	1012	<1.00	53.4	159	1930	1.46	<1.00	1686.700	1.667	89.002	265.005	3216.731	2.433	1.667
1	EWG-OL-6257-Mod-12B-8Ca-CCC	1	13	S04	118	84.8	6.91	54.1	12.5	<1.00	<1.00	196.671	141.336	11.517	90.168	20.834	1.667	1.667
1	EA	1	14	S15	23.6	<1.00	<1.00	6.98	52.3	<1.00	33.7	393.334	16.667	16.667	116.334	871.668	16.667	561.668
1	ARM-1	1	15	S07	13.9	<1.00	<1.00	8.44	21.7	<1.00	35.1	23.167	1.667	1.667	14.067	36.167	1.667	58.501
1	EWG-OL-4744-Mod-7.5Fe-1Zr-Q	1	16	S41	114	1.98	<1.00	<1.00	509	<1.00	14.0	190.004	3.300	1.667	1.667	848.350	1.667	23.334
1	EWG-OL-3063-Mod-1Zr-3Li-Q	1	17	S44	538	<1.00	10.5	72.7	86.9	2.27	19.5	896.685	1.667	17.500	121.169	144.836	3.783	32.501
1	EWG-OL-6489-Mod-11B-15Na-Q	1	18	S19	172	<1.00	46.9	57.9	388	27.3	1.52	286.672	1.667	78.168	96.502	646.680	45.501	2.533
1	EWG-OL-6311-Mod-Reduced-Na-K-Q	1	19	S48	103	<1.00	<1.00	59.0	232	22.2	47.5	171.670	1.667	1.667	98.335	386.674	37.001	79.168
1	soln std	1	20	std-s1-3	20.5	<1.00	10.7	10.2	83.3	<1.00	49.8	20.500	1.000	10.700	10.200	83.300	1.000	49.800
1	soln std	2	1	std-s2-1	19.8	<1.00	9.87	9.77	82.5	<1.00	49.6	19.800	1.000	9.870	9.770	82.500	1.000	49.600
1	EWG-OL-4744-Mod-7.5Fe-1Zr-Q	2	2	S18	114	1.53	<1.00	<1.00	517	<1.00	14.2	190.004	2.550	1.667	1.667	861.684	1.667	23.667
1	EWG-OL-3063-Mod-1Zr-3Li-Q	2	3	S21	562	<1.00	9.53	73.4	86.9	2.26	20.0	936.685	1.667	15.884	122.336	144.836	3.767	33.334
1	EWG-OL-6257-Mod-12B-8Ca-Q	2	4	S51	7.02	2.22	2.22	4.17	4.82	<1.00	6.59	11.700	3.700	3.700	6.950	8.033	1.667	10.984
1	EWG-OL-6489-Mod-11B-15Na-Q	2	5	S16	178	<1.00	48.1	59.7	400	28.7	1.77	296.673	1.667	80.168	99.502	666.680	47.834	2.950
1	EWG-OL-5385-Mod-12B-17Na-Q	2	6	S38	45.5	1.83	27.5	26.4	203	<1.00	18.7	75.835	3.050	45.834	44.001	338.340	1.667	31.167
1	EWG-OL-5385-Mod-12B-17Na-CCC	2	7	S39	832	4.00	51.8	330	2070	<1.00	31.3	1386.694	6.667	86.335	550.011	3450.069	1.667	52.168
1	EWG-OL-1755-Mod-8Fe-10B-CCC	2	8	S52	12.5	<1.00	3.80	8.20	6.29	<1.00	40.9	20.834	1.667	6.333	13.667	10.484	1.667	68.168
1	EWG-OL-6311-Mod-Reduced-Na-K-CCC	2	9	S33	1800	<1.00	<1.00	744	2010	<1.00	40.5	3000.060	1.667	1.667	1240.025	3350.067	1.667	67.501
1	soln std	2	10	std-s2-2	18.3	<1.00	9.89	9.71	82.4	<1.00	49.0	18.300	1.000	9.890	9.710	82.400	1.000	49.000
1	EWG-Centroid-2-R1-Q	2	11	S49	15.1	<1.00	0.766	4.08	19.6	1.08	16.8	25.167	1.667	1.277	6.800	32.667	1.800	28.001
1	ARM-1	2	12	S40	13.6	<1.00	<1.00	8.03	21.4	<1.00	35.0	22.667	1.667	1.667	13.384	35.667	1.667	58.335
1	EWG-OL-1755-Mod-8Fe-10B-Q	2	13	S10	9.19	<1.00	3.67	8.33	5.47	<1.00	39.2	15.317	1.667	6.117	13.884	9.117	1.667	65.335
1	EWG-OL-3063-Mod-1Zr-3Li-CCC	2	14	S20	571	<1.00	9.94	78.9	93.7	2.90	20.9	951.686	1.667	16.567	131.503	156.170	4.833	34.834
1	EWG-OL-6311-Mod-Reduced-Na-K-Q	2	15	S42	98.1	<1.00	<1.00	58.3	232	21.47	46.3	163.503	1.667	1.667	97.169	386.674	35.784	77.168
1	EA	2	16	S50	20.6	<1.00	<1.00	6.40	50.8	<1.00	32.7	343.334	16.667	16.667	106.667	846.668	16.667	545.001
1	EWG-OL-6257-Mod-12B-8Ca-CCC	2	17	S03	119	92.1	7.01	58.1	13.5	<1.00	<1.00	198.337	153.503	11.684	96.835	22.500	1.667	1.667
1	EWG-OL-6489-Mod-11B-15Na-CCC	2	18	S13	985	<1.00	55.9	165	1880	1.26	<1.00	1641.700	1.667	93.169	275.006	3133.396	2.100	1.667
1	soln std	2	19	std-s2-3	18.2	<1.00	9.89	9.79	82.5	<1.00	49.0	18.200	1.000	9.890	9.790	82.500	1.000	49.000
1	soln std	3	1	std-s3-1	19.8	<1.00	10.3	10.1	81.9	<1.00	49.5	19.800	1.000	10.300	10.100	81.900	1.000	49.500
1	EWG-OL-3063-Mod-1Zr-3Li-Q	3	2	S47	549	<1.00	9.81	71.3	84.3	2.28	19.4	915.018	1.667	16.350	118.836	140.503	3.800	32.334
1	ARM-1	3	3	S43	10.7	<1.00	<1.00	8.30	21.4	<1.00	35.3	17.834	1.667	1.667	13.834	35.667	1.667	58.835

Table B-1. PCT Measurements for HLW Set 3 Study Glasses (ar – as received) (continued)

Set	Glass ID (w HT)	Block	Seq	Lab ID	B ar	Ca ar	K ar	Li ar	Na ar	P ar	Si ar	B (ppm)	Ca (ppm)	K (ppm)	Li (ppm)	Na (ppm)	P (ppm)	Si (ppm)
1	EA	3	4	S08	17.3	<1.00	<1.00	6.57	50.1	<1.00	31.6	288.334	16.667	16.667	109.500	835.002	16.667	526.668
1	EWG-OL-1755-Mod-8Fe-10B-Q	3	5	S36	5.69	<1.00	3.76	8.05	5.58	<1.00	35.4	9.484	1.667	6.267	13.417	9.300	1.667	59.001
1	EWG-OL-6489-Mod-11B-15Na-Q	3	6	S09	155	<1.00	43.2	53.2	361	24.4	1.78	258.339	1.667	72.001	88.668	601.679	40.667	2.967
1	EWG-OL-3063-Mod-1Zr-3Li-CCC	3	7	S26	581	<1.00	9.76	77.3	89.2	2.90	21.3	968.353	1.667	16.267	128.836	148.670	4.833	35.501
1	EWG-OL-4744-Mod-7.5Fe-1Zr-Q	3	8	S12	108	1.83	<1.00	<1.00	477	<1.00	13.0	180.004	3.050	1.667	1.667	795.016	1.667	21.667
1	EWG-OL-6257-Mod-12B-8Ca-Q	3	9	S22	3.66	2.54	2.56	4.36	5.00	<1.00	6.36	6.100	4.233	4.267	7.267	8.334	1.667	10.600
1	EWG-OL-5385-Mod-12B-17Na-Q	3	10	S11	40.0	2.07	24.0	23.7	178	<1.00	16.6	66.668	3.450	40.001	39.501	296.673	1.667	27.667
1	soln std	3	11	std-s3-2	19.2	<1.00	10.2	9.83	80.1	<1.00	47.9	19.200	1.000	10.200	9.830	80.100	1.000	47.900
1	EWG-OL-6257-Mod-12B-8Ca-CCC	3	12	S24	109	82.8	6.72	53.2	12.4	<1.00	<1.00	181.670	138.003	11.200	88.668	20.667	1.667	1.667
1	EWG-OL-6311-Mod-Reduced-Na-K-Q	3	13	S46	101	<1.00	<1.00	55.7	215	21.21	44.7	168.337	1.667	1.667	92.835	358.341	35.351	74.501
1	blank	3	14	S53	<1.00	<1.00	<1.00	<1.00	1.14	<1.00	<1.00	1.667	1.667	1.667	1.667	1.900	1.667	1.667
1	EWG-OL-1755-Mod-8Fe-10B-CCC	3	15	S06	4.78	<1.00	4.17	8.37	6.56	<1.00	39.7	7.967	1.667	6.950	13.950	10.934	1.667	66.168
1	EWG-OL-5385-Mod-12B-17Na-CCC	3	16	S17	773	4.31	50.8	308	2100	<1.00	29.1	1288.359	7.183	84.668	513.344	3500.070	1.667	48.501
1	EWG-OL-6311-Mod-Reduced-Na-K-CCC	3	17	S31	1660	<1.00	<1.00	714	1920	<1.00	39.9	2766.722	1.667	1.667	1190.024	3200.064	1.667	66.501
1	EWG-OL-6489-Mod-11B-15Na-CCC	3	18	S27	981	<1.00	55.2	162	1860	1.33	<1.00	1635.033	1.667	92.002	270.005	3100.062	2.217	1.667
1	EWG-Centroid-2-R1-Q	3	19	S05	21.3	<1.00	1.23	4.27	18.9	1.07	16.5	35.501	1.667	2.050	7.117	31.501	1.783	27.501
1	soln std	3	20	std-s3-3	20.3	<1.00	9.16	9.25	73.5	<1.00	45.0	20.300	1.000	9.160	9.250	73.500	1.000	45.000
2	soln std	1	1	std-t1-1	18.8	<1.00	9.75	9.61	77.6	<1.00	47.4	18.800	1.000	9.750	9.610	77.600	1.000	47.400
2	EWG-OL-10278-Mod-15B-1Zr-CCC	1	2	T32	236	2.28	72.3	133	485	<1.00	15.8	393.341	3.800	120.502	221.671	808.350	1.667	26.334
2	EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	1	3	T48	50.3	<1.00	13.7	27.6	163	<1.00	17.9	83.835	1.667	22.834	46.001	271.672	1.667	29.834
2	EWG-Centroid-2-R1-Q	1	4	T03	9.70	<1.00	1.21	4.05	18.2	1.17	16.1	16.167	1.667	2.017	6.750	30.334	1.950	26.834
2	EWG-OL-8548-Mod-1Zr-Q	1	5	T05	11.3	<1.00	<1.00	<1.00	66.7	5.33	29.6	18.834	1.667	1.667	1.667	111.169	8.884	49.334
2	EWG-OL-11318-Mod-1Zr-Q	1	6	T11	138	<1.00	<1.00	<1.00	226	<1.00	15.8	230.005	1.667	1.667	1.667	376.674	1.667	26.334
2	EWG-OL-8548-Mod-1Zr-CCC	1	7	T35	1360	<1.00	<1.00	1.47	1950	151	6.32	2266.712	1.667	1.667	2.450	3250.065	251.672	10.534
2	EWG-OL-6080-Q	1	8	T24	17.5	4.66	4.37	<1.00	8.48	<1.00	2.09	29.167	7.767	7.283	1.667	14.134	1.667	3.483
2	ARM-1	1	9	T30	12.4	<1.00	<1.00	8.15	21.2	<1.00	35.9	20.667	1.667	1.667	13.584	35.334	1.667	59.835
2	EA	1	10	T07	24.4	<1.00	<1.00	8.25	63.7	<1.00	42.1	406.667	16.667	16.667	137.500	1061.669	16.667	701.668
2	soln std	1	11	std-t1-2	21.3	<1.00	10.3	10.1	81.4	<1.00	50.3	21.300	1.000	10.300	10.100	81.400	1.000	50.300
2	EWG-OL-14547-Mod-Reduced-Alkali-1Zr-CCC	1	12	T46	1020	3.19	3.54	533	1150	<1.00	52.1	1700.034	5.317	5.900	888.351	1916.705	1.667	86.835
2	EWG-OL-8548-Q	1	13	T50	17.5	<1.00	<1.00	<1.00	75.4	5.95	23.7	29.167	1.667	1.667	1.667	125.669	9.917	39.501
2	EWG-OL-10278-Mod-15B-1Zr-Q	1	14	T45	34.6	1.24	17.0	21.1	106	<1.00	14.8	57.668	2.067	28.334	35.167	176.670	1.667	24.667
2	EWG-OL-6080-CCC	1	15	T25	12.4	3.30	3.39	<1.00	6.77	<1.00	3.51	20.667	5.500	5.650	1.667	11.284	1.667	5.850
2	EWG-OL-15698-Mod-Low-Na-CCC	1	16	T10	276	24.73	<1.00	152	642	<1.00	5.16	460.009	41.217	1.667	253.338	1070.021	1.667	8.600
2	blank	1	17	T41	3.09	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	5.150	1.667	1.667	1.667	1.667	1.667	1.667
2	EWG-OL-15698-Mod-Low-Na-Q	1	18	T21	205	<1.00	<1.00	80.4	626	<1.00	24.3	341.674	1.667	1.667	134.003	1043.354	1.667	40.501
2	EWG-OL-11318-Mod-1Zr-CCC	1	19	T31	132	<1.00	<1.00	<1.00	210	<1.00	15.7	220.004	1.667	1.667	1.667	350.007	1.667	26.167
2	soln std	1	20	std-t1-3	20.6	<1.00	9.51	9.52	75.4	<1.00	47.2	20.600	1.000	9.510	9.520	75.400	1.000	47.200
2	soln std	2	1	std-t2-1	21.8	<1.00	10.2	9.88	83.4	<1.00	51.0	21.800	1.000	10.200	9.880	83.400	1.000	51.000
2	EWG-OL-14547-Mod-Reduced-Alkali-1Zr-CCC	2	2	T22	800	3.44	3.64	544	1112	<1.00	56.9	1333.360	5.733	6.067	906.685	1853.370	1.667	94.835
2	ARM-1	2	3	T18	12.4	<1.00	<1.00	8.17	22.0	<1.00	37.2	20.667	1.667	1.667	13.617	36.667	1.667	62.001
2	EWG-OL-11318-Mod-1Zr-CCC	2	4	T23	164	<1.00	<1.00	<1.00	189	<1.00	17.0	273.339	1.667	1.667	1.667	315.006	1.667	28.334
2	EWG-OL-15698-Mod-Low-Na-Q	2	5	T47	271	<1.00	<1.00	86.1	600	<1.00	26.7	451.676	1.667	1.667	143.503	1000.020	1.667	44.501

Table B-1. PCT Measurements for HLW Set 3 Study Glasses (ar – as received) (continued)

Set	Glass ID (w HT)	Block	Seq	Lab ID	B ar	Ca ar	K ar	Li ar	Na ar	P ar	Si ar	B (ppm)	Ca (ppm)	K (ppm)	Li (ppm)	Na (ppm)	P (ppm)	Si (ppm)
2	EWG-OL-10278-Mod-15B-1Zr-Q	2	6	T02	46.6	1.23	19.4	23.3	123	<1.00	16.7	77.668	2.050	32.334	38.834	205.004	1.667	27.834
2	EWG-Centroid-2-R1-Q	2	7	T20	15.1	<1.00	1.05	4.08	19.2	<1.00	17.3	25.167	1.667	1.750	6.800	32.001	1.667	28.834
2	EWG-OL-11318-Mod-1Zr-Q	2	8	T08	164	<1.00	<1.00	<1.00	254	<1.00	17.1	273.339	1.667	1.667	1.667	423.342	1.667	28.501
2	EWG-OL-8548-Mod-1Zr-CCC	2	9	T34	1350	<1.00	<1.00	1.33	1980	159.28	6.70	2250.045	1.667	1.667	2.217	3300.066	265.472	11.167
2	EWG-OL-6080-CCC	2	10	T04	12.8	3.37	3.65	<1.00	7.53	<1.00	3.77	21.334	5.617	6.083	1.667	12.550	1.667	6.283
2	soln std	2	11	std-t2-2	21.8	<1.00	11.2	10.6	91.6	<1.00	55.6	21.800	1.000	11.200	10.600	91.600	1.000	55.600
2	EA	2	12	T13	24.3	<1.00	<1.00	6.93	56.2	<1.00	36.5	405.001	16.667	16.667	115.500	936.669	16.667	608.335
2	EWG-OL-15698-Mod-Low-Na-CCC	2	13	T16	301	24.05	<1.00	159	742	<1.00	5.53	501.677	40.084	1.667	265.005	1236.691	1.667	9.217
2	EWG-OL-8548-Mod-1Zr-Q	2	14	T14	16.5	<1.00	<1.00	<1.00	72.04	5.35	31.9	27.501	1.667	1.667	1.667	120.069	8.917	53.168
2	EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	2	15	T26	58.9	<1.00	14.3	28.7	175	<1.00	18.6	98.169	1.667	23.834	47.834	291.673	1.667	31.001
2	EWG-OL-6080-Q	2	16	T17	17.0	4.71	4.40	<1.00	8.77	<1.00	2.06	28.334	7.850	7.333	1.667	14.617	1.667	3.433
2	EWG-OL-8548-Q	2	17	T29	16.1	<1.00	<1.00	<1.00	78.3	6.02	24.7	26.834	1.667	1.667	1.667	130.503	10.034	41.167
2	EWG-OL-10278-Mod-15B-1Zr-CCC	2	18	T39	255	2.33	77.6	139.22	492	<1.00	16.9	425.009	3.883	129.336	232.038	820.016	1.667	28.167
2	soln std	2	19	std-t2-3	20.5	<1.00	10.8	10.3	88.3	<1.00	53.7	20.500	1.000	10.800	10.300	88.300	1.000	53.700
2	soln std	3	1	std-t3-1	19.6	<1.00	9.81	9.69	81.4	<1.00	49.4	19.600	1.000	9.810	9.690	81.400	1.000	49.400
2	EWG-OL-15698-Mod-Low-Na-CCC	3	2	T33	298	24.75	<1.00	140	589	<1.00	4.84	496.677	41.251	1.667	233.338	981.686	1.667	8.067
2	EWG-OL-6080-Q	3	3	T49	13.9	5.08	4.14	<1.00	8.83	<1.00	2.16	23.167	8.467	6.900	1.667	14.717	1.667	3.600
2	ARM-1	3	4	T37	9.39	<1.00	<1.00	7.69	20.7	<1.00	34.1	15.650	1.667	1.667	12.817	34.501	1.667	56.834
2	EWG-OL-11318-Mod-1Zr-CCC	3	5	T44	135	<1.00	<1.00	<1.00	220	<1.00	15.6	225.005	1.667	1.667	1.667	366.674	1.667	26.001
2	EWG-OL-15698-Mod-Low-Na-Q	3	6	T19	213	<1.00	<1.00	82.5	596	<1.00	25.5	355.007	1.667	1.667	137.503	993.353	1.667	42.501
2	EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q	3	7	T43	49.2	<1.00	13.2	27.0	160	<1.00	17.2	82.002	1.667	22.000	45.001	266.672	1.667	28.667
2	EWG-OL-14547-Mod-Reduced-Alkali-1Zr-CCC	3	8	T09	787	3.52	3.37	528	916	<1.00	50.5	1311.693	5.867	5.617	880.018	1526.697	1.667	84.168
2	EWG-OL-10278-Mod-15B-1Zr-CCC	3	9	T15	225	2.76	72.8	132	462	<1.00	16.4	375.008	4.600	121.336	220.004	770.015	1.667	27.334
2	EWG-OL-11318-Mod-1Zr-Q	3	10	T36	140	<1.00	<1.00	<1.00	230	<1.00	15.6	233.338	1.667	1.667	1.667	383.341	1.667	26.001
2	soln std	3	11	std-t3-2	21.2	<1.00	9.89	9.64	81.0	<1.00	49.2	21.200	1.000	9.890	9.640	81.000	1.000	49.200
2	EA	3	12	T42	23.0	<1.00	<1.00	7.90	62.8	<1.00	40.4	383.334	16.667	16.667	131.667	1046.669	16.667	673.335
2	EWG-Centroid-2-R1-Q	3	13	T28	10.3	<1.00	1.01	3.95	18.7	1.07	16.3	17.167	1.667	1.683	6.583	31.167	1.783	27.167
2	EWG-OL-8548-Mod-1Zr-CCC	3	14	T38	1360	<1.00	<1.00	1.33	2010	149	6.38	2266.712	1.667	1.667	2.217	3350.067	248.338	10.634
2	EWG-OL-10278-Mod-15B-1Zr-Q	3	15	T12	37.9	1.62	17.8	21.7	113	<1.00	15.8	63.168	2.700	29.667	36.167	188.337	1.667	26.334
2	EWG-OL-8548-Mod-1Zr-Q	3	16	T27	13.5	<1.00	<1.00	<1.00	66.6	5.08	29.1	22.500	1.667	1.667	1.667	111.002	8.467	48.501
2	EWG-OL-6080-CCC	3	17	T06	12.5	3.94	3.28	<1.00	7.32	<1.00	4.04	20.834	6.567	5.467	1.667	12.200	1.667	6.733
2	blank	3	18	T40	1.96	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	3.267	1.667	1.667	1.667	1.667	1.667	1.667
2	EWG-OL-8548-Q	3	19	T01	13.9	<1.00	<1.00	<1.00	72.2	5.61	22.7	23.167	1.667	1.667	1.667	120.336	9.350	37.834
2	soln std	3	20	std-t3-3	19.4	<1.00	9.27	9.26	77.0	<1.00	46.6	19.400	1.000	9.270	9.260	77.000	1.000	46.600

Table B-2. Set 1 PCT Leachate pH Values for the HLW Set 3 Study Glasses

Identifier	pH		Identifier	pH
BLANK-1	6.97		EWG-OL-5385-Mod-12B-17Na-Q-1	11.84
BLANK-2	6.88		EWG-OL-5385-Mod-12B-17Na-Q-2	11.8
ARM-1-1	10.17		EWG-OL-5385-Mod-12B-17Na-Q-3	11.77
ARM-1-2	10.17		EWG-OL-6257-Mod-12B-8Ca-CCC-1	10.49
ARM-1-3	10.19		EWG-OL-6257-Mod-12B-8Ca-CCC-2	10.5
EA-1	11.51		EWG-OL-6257-Mod-12B-8Ca-CCC-3	10.49
EA-2	11.52		EWG-OL-6257-Mod-12B-8Ca-Q-1	10.17
EA-3	11.51		EWG-OL-6257-Mod-12B-8Ca-Q-2	10.15
EWG-OL-1755-Mod-8Fe-10B-CCC-1	9.91		EWG-OL-6257-Mod-12B-8Ca-Q-3	10.16
EWG-OL-1755-Mod-8Fe-10B-CCC-2	9.91		EWG-OL-6311-Mod-Reduced-Na-K-CCC-1	11.91
EWG-OL-1755-Mod-8Fe-10B-CCC-3	9.86		EWG-OL-6311-Mod-Reduced-Na-K-CCC-2	11.92
EWG-OL-1755-Mod-8Fe-10B-Q-1	9.86		EWG-OL-6311-Mod-Reduced-Na-K-CCC-3	11.92
EWG-OL-1755-Mod-8Fe-10B-Q-2	9.87		EWG-OL-6311-Mod-Reduced-Na-K-Q-1	11.5
EWG-OL-1755-Mod-8Fe-10B-Q-3	9.86		EWG-OL-6311-Mod-Reduced-Na-K-Q-2	11.48
EWG-OL-3063-Mod-1Zr-3Li-CCC-1	8.56		EWG-OL-6311-Mod-Reduced-Na-K-Q-3	11.49
EWG-OL-3063-Mod-1Zr-3Li-CCC-2	8.55		EWG-OL-6489-Mod-11B-15Na-CCC-1	10.92
EWG-OL-3063-Mod-1Zr-3Li-CCC-3	8.55		EWG-OL-6489-Mod-11B-15Na-CCC-2	10.91
EWG-OL-3063-Mod-1Zr-3Li-Q-1	8.55		EWG-OL-6489-Mod-11B-15Na-CCC-3	10.91
EWG-OL-3063-Mod-1Zr-3Li-Q-2	8.55		EWG-OL-6489-Mod-11B-15Na-Q-1	11.49
EWG-OL-3063-Mod-1Zr-3Li-Q-3	8.56		EWG-OL-6489-Mod-11B-15Na-Q-2	11.49
EWG-OL-4744-Mod-7.5Fe-1Zr-Q-1	11.75		EWG-OL-6489-Mod-11B-15Na-Q-3	11.52
EWG-OL-4744-Mod-7.5Fe-1Zr-Q-2	11.75		EWG-Centroid-2-R1-Q-1	9.5
EWG-OL-4744-Mod-7.5Fe-1Zr-Q-3	11.76		EWG-Centroid-2-R1-Q-2	9.45
EWG-OL-5385-Mod-12B-17Na-CCC-1	12.3		EWG-Centroid-2-R1-Q-3	9.46
EWG-OL-5385-Mod-12B-17Na-CCC-2	12.32			
EWG-OL-5385-Mod-12B-17Na-CCC-3	12.35			

Table B-3. Set 2 PCT Leachate pH Values for the HLW Set 3 Study Glasses

Identifier	pH		Identifier	pH
BLANK-1	6.9		EWG-OL-15698-Mod-Low-Na-CCC-1	12.06
BLANK-2	6.88		EWG-OL-15698-Mod-Low-Na-CCC-2	12.08
ARM-1-1	10.11		EWG-OL-15698-Mod-Low-Na-CCC-3	12.08
ARM-1-2	10.12		EWG-OL-15698-Mod-Low-Na-Q-1	11.98
ARM-1-3	10.13		EWG-OL-15698-Mod-Low-Na-Q-2	11.99
EA-1	11.46		EWG-OL-15698-Mod-Low-Na-Q-3	11.99
EA-2	11.49		EWG-OL-6080-CCC-1	8.88
EA-3	11.51		EWG-OL-6080-CCC-2	8.71
EWG-OL-10278-Mod-15B-1Zr-CCC-1	11.86		EWG-OL-6080-CCC-3	8.68
EWG-OL-10278-Mod-15B-1Zr-CCC-2	11.85		EWG-OL-6080-Q-1	8.72
EWG-OL-10278-Mod-15B-1Zr-CCC-3	11.87		EWG-OL-6080-Q-2	8.7
EWG-OL-10278-Mod-15B-1Zr-Q-1	11.34		EWG-OL-6080-Q-3	8.65
EWG-OL-10278-Mod-15B-1Zr-Q-2	11.34		EWG-OL-8548-Mod-1Zr-CCC-1	9.43
EWG-OL-10278-Mod-15B-1Zr-Q-3	11.35		EWG-OL-8548-Mod-1Zr-CCC-2	9.38
EWG-OL-11318-Mod-1Zr-CCC-1	9.21		EWG-OL-8548-Mod-1Zr-CCC-3	9.36
EWG-OL-11318-Mod-1Zr-CCC-2	9.2		EWG-OL-8548-Mod-1Zr-Q-1	10.16
EWG-OL-11318-Mod-1Zr-CCC-3	9.2		EWG-OL-8548-Mod-1Zr-Q-2	10.2
EWG-OL-11318-Mod-1Zr-Q-1	9.24		EWG-OL-8548-Mod-1Zr-Q-3	10.21
EWG-OL-11318-Mod-1Zr-Q-2	9.24		EWG-OL-8548-Q-1	10.32
EWG-OL-11318-Mod-1Zr-Q-3	9.23		EWG-OL-8548-Q-2	10.29
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-CCC-1	12.11		EWG-OL-8548-Q-3	10.32
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-CCC-2	12.13		EWG-Centroid-2-R1-Q-1	9.39
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-CCC-3	12.14		EWG-Centroid-2-R1-Q-2	9.36
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q-1	11.61		EWG-Centroid-2-R1-Q-3	9.36
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q-2	11.57			
EWG-OL-14547-Mod-Reduced-Alkali-1Zr-Q-3	11.54			

Exhibit B-1. PCT Measurements in Analytical Sequence by Analytical Set

Set=1, Analyte=log[B ppm]
Variability Chart for log[(ppm)]

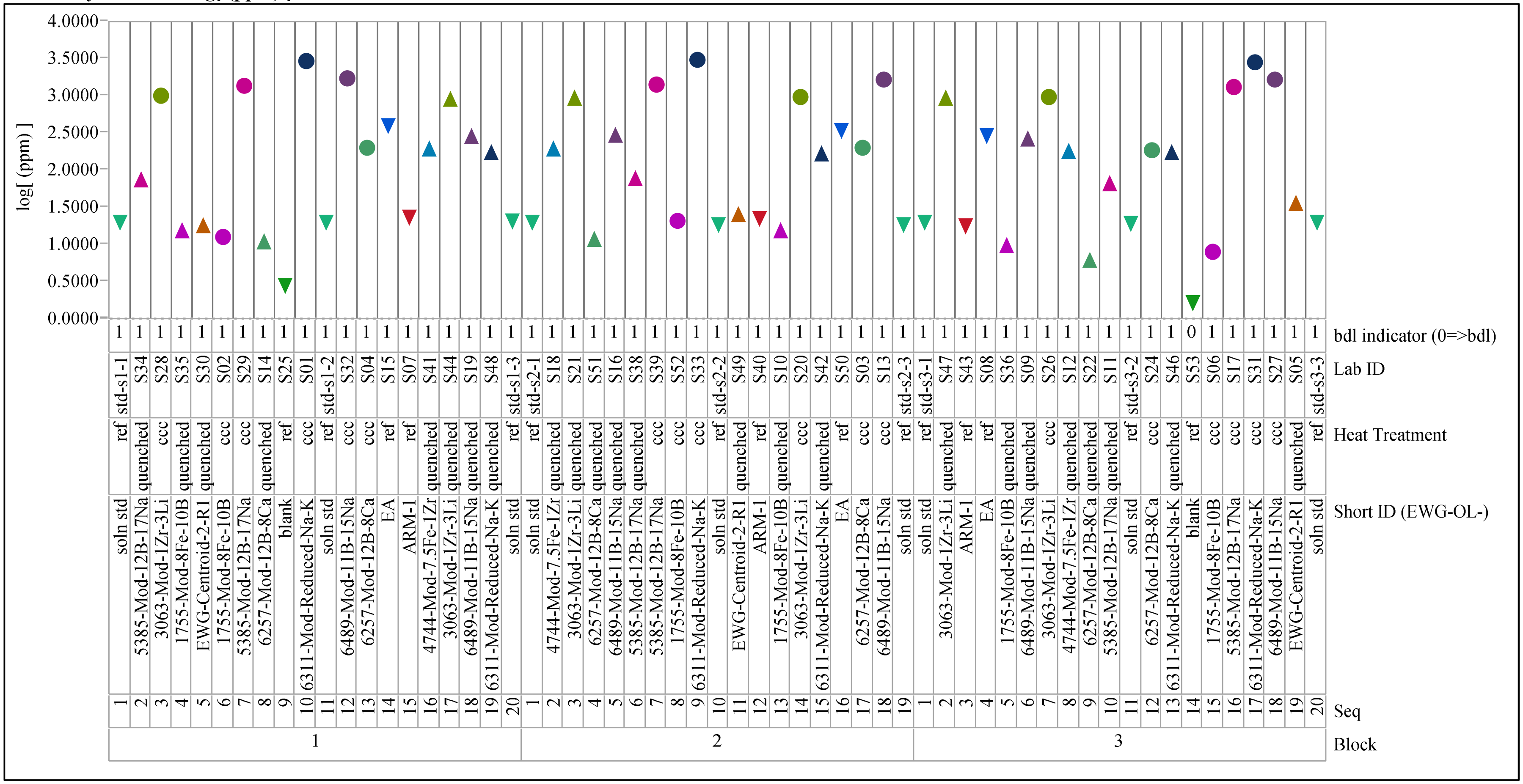


Exhibit B-1. PCT Measurements in Analytical Sequence by Analytical Set (continued)

Set=1, Analyte=log[Ca ppm]
Variability Chart for log[(ppm)]

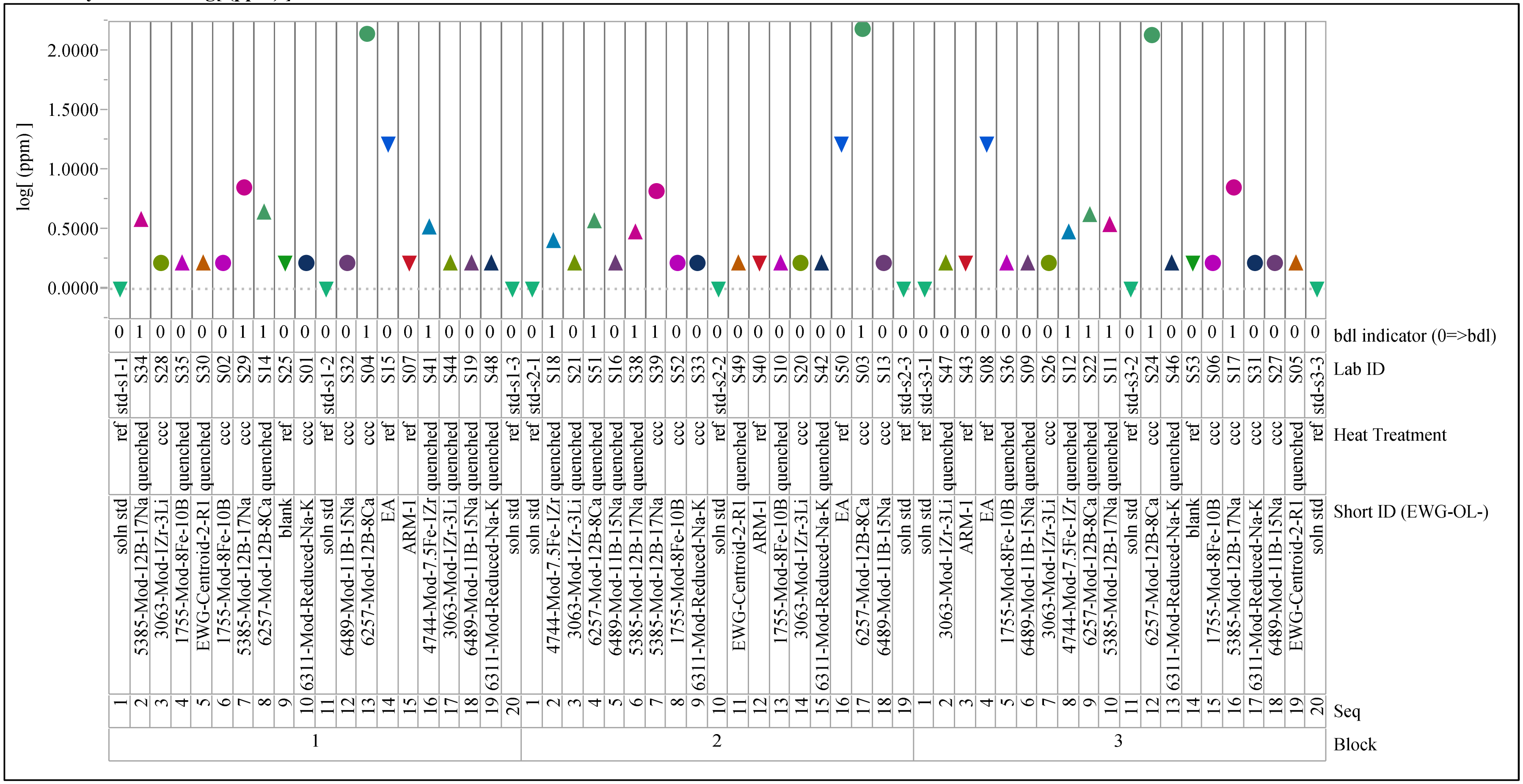


Exhibit B-1. PCT Measurements in Analytical Sequence by Analytical Set (continued)

Set=1, Analyte=log[K ppm]
Variability Chart for log[(ppm)]

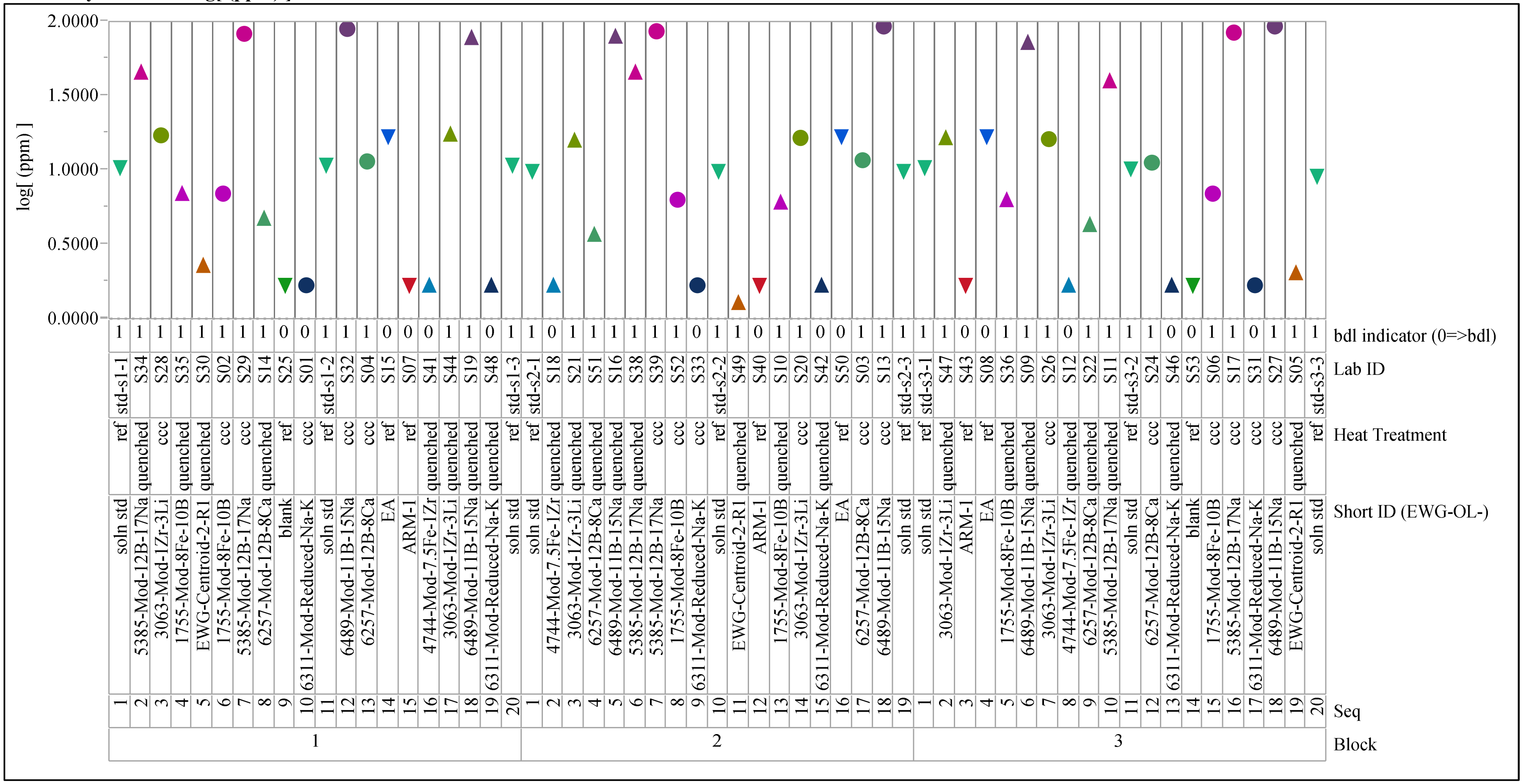


Exhibit B-1. PCT Measurements in Analytical Sequence by Analytical Set (continued)

Set=1, Analyte=log[Li ppm]
Variability Chart for log[(ppm)]

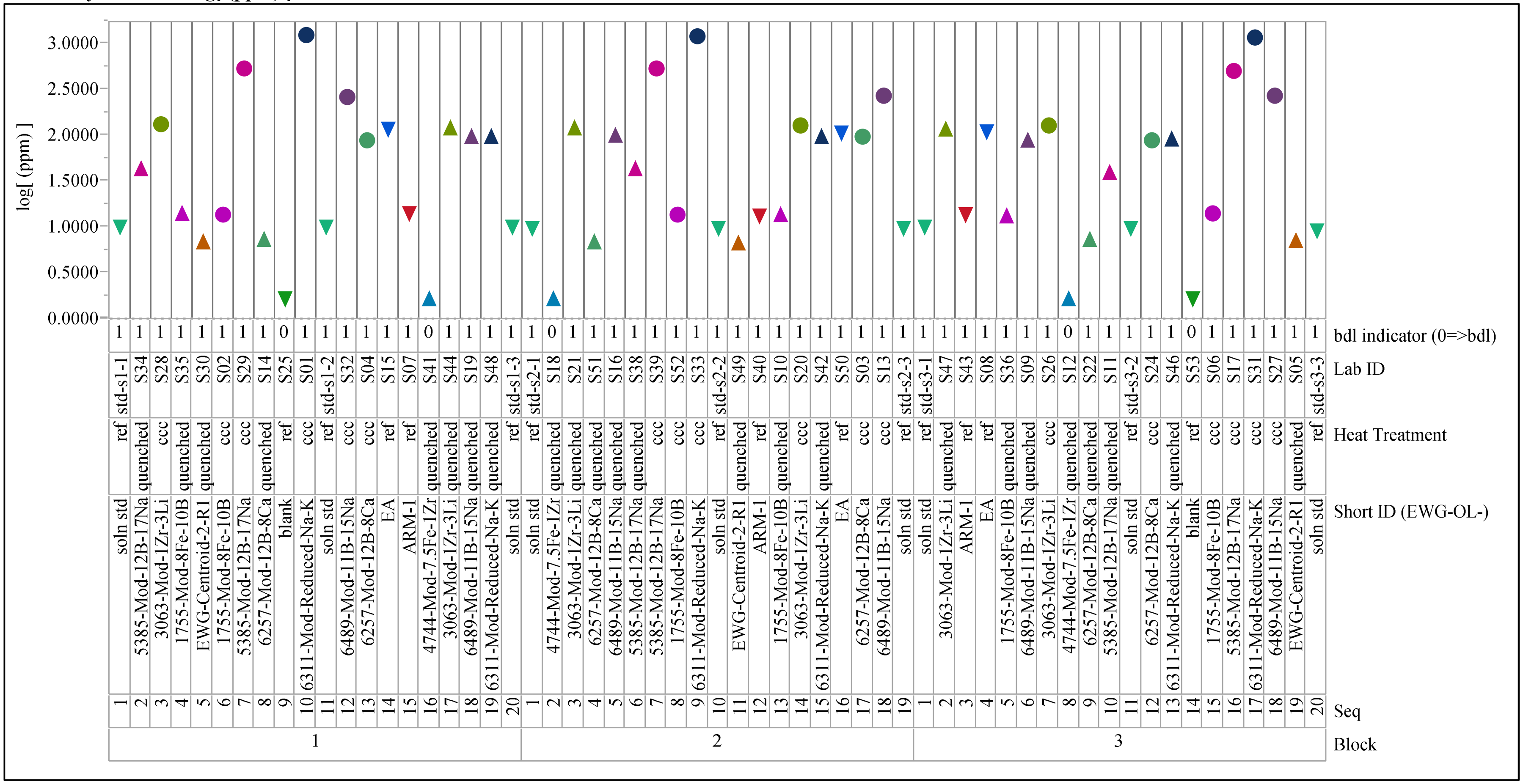


Exhibit B-1. PCT Measurements in Analytical Sequence by Analytical Set (continued)

Set=1, Analyte=log[Na ppm]
Variability Chart for log[(ppm)]

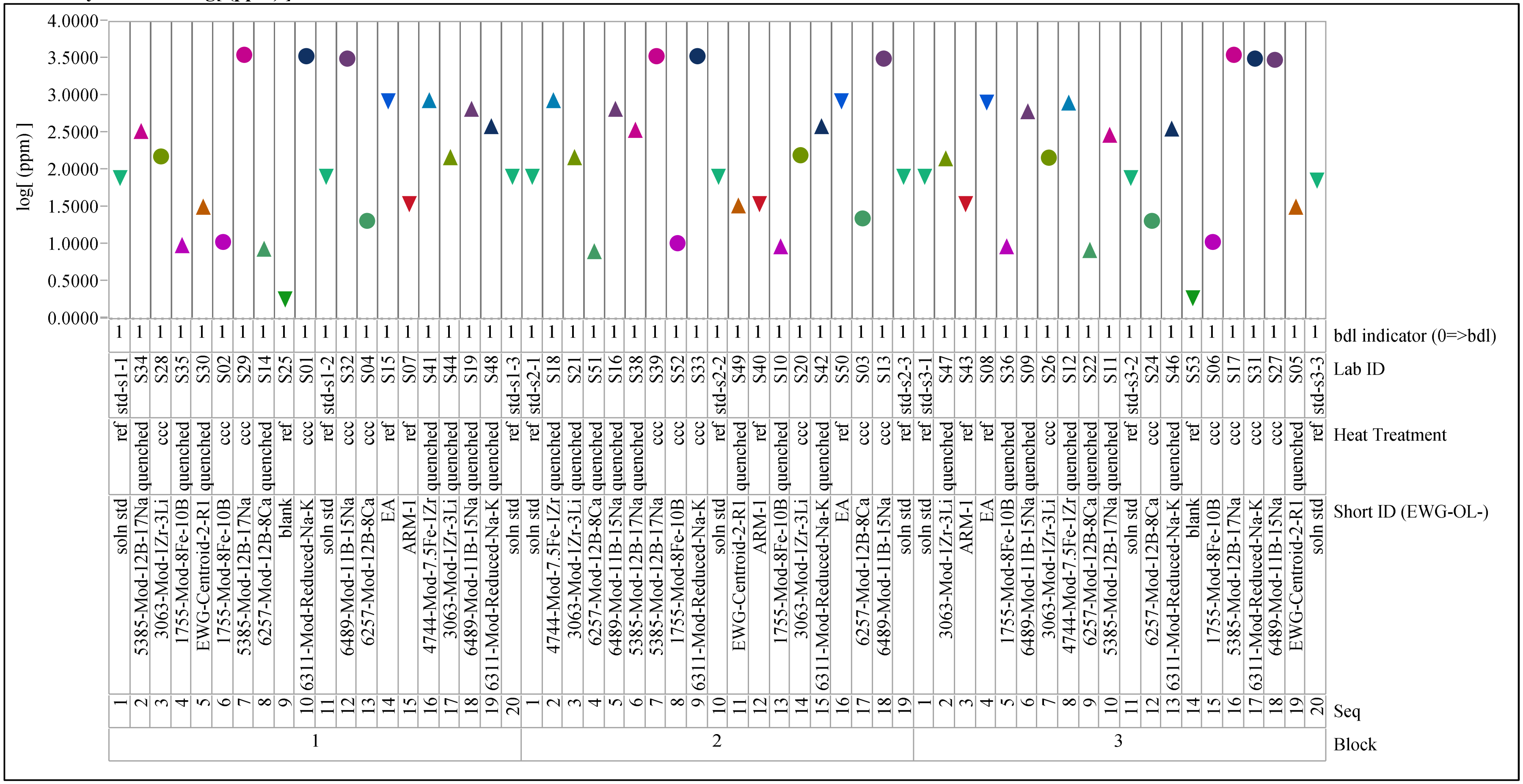


Exhibit B-1. PCT Measurements in Analytical Sequence by Analytical Set (continued)

Set=1, Analyte=log[P ppm]
Variability Chart for log[(ppm)]

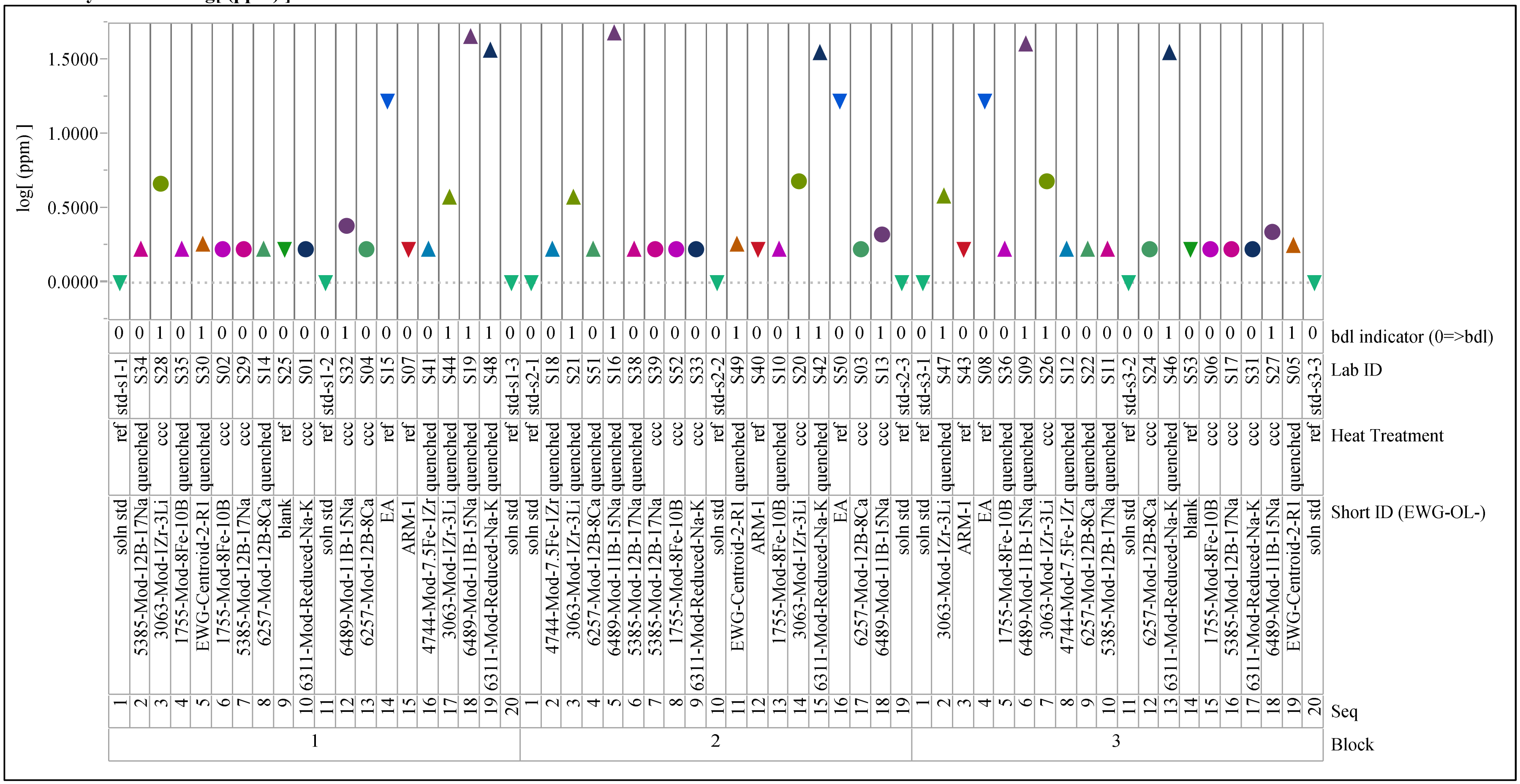


Exhibit B-1. PCT Measurements in Analytical Sequence by Analytical Set (continued)

Set=1, Analyte=log[Si ppm]
Variability Chart for log[(ppm)]

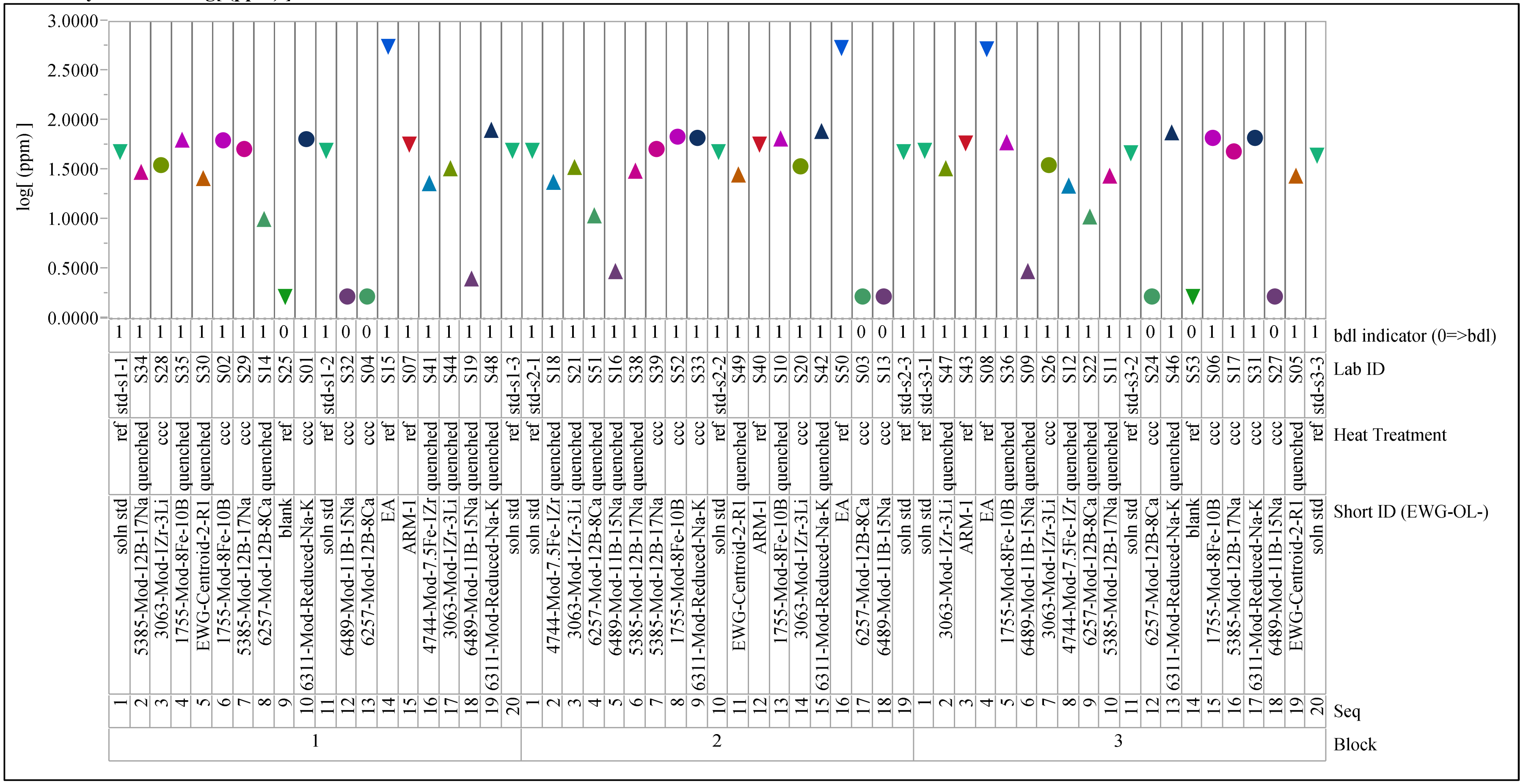


Exhibit B-1. PCT Measurements in Analytical Sequence by Analytical Set (continued)

Set=2, Analyte=log[B ppm]
Variability Chart for log[(ppm)]

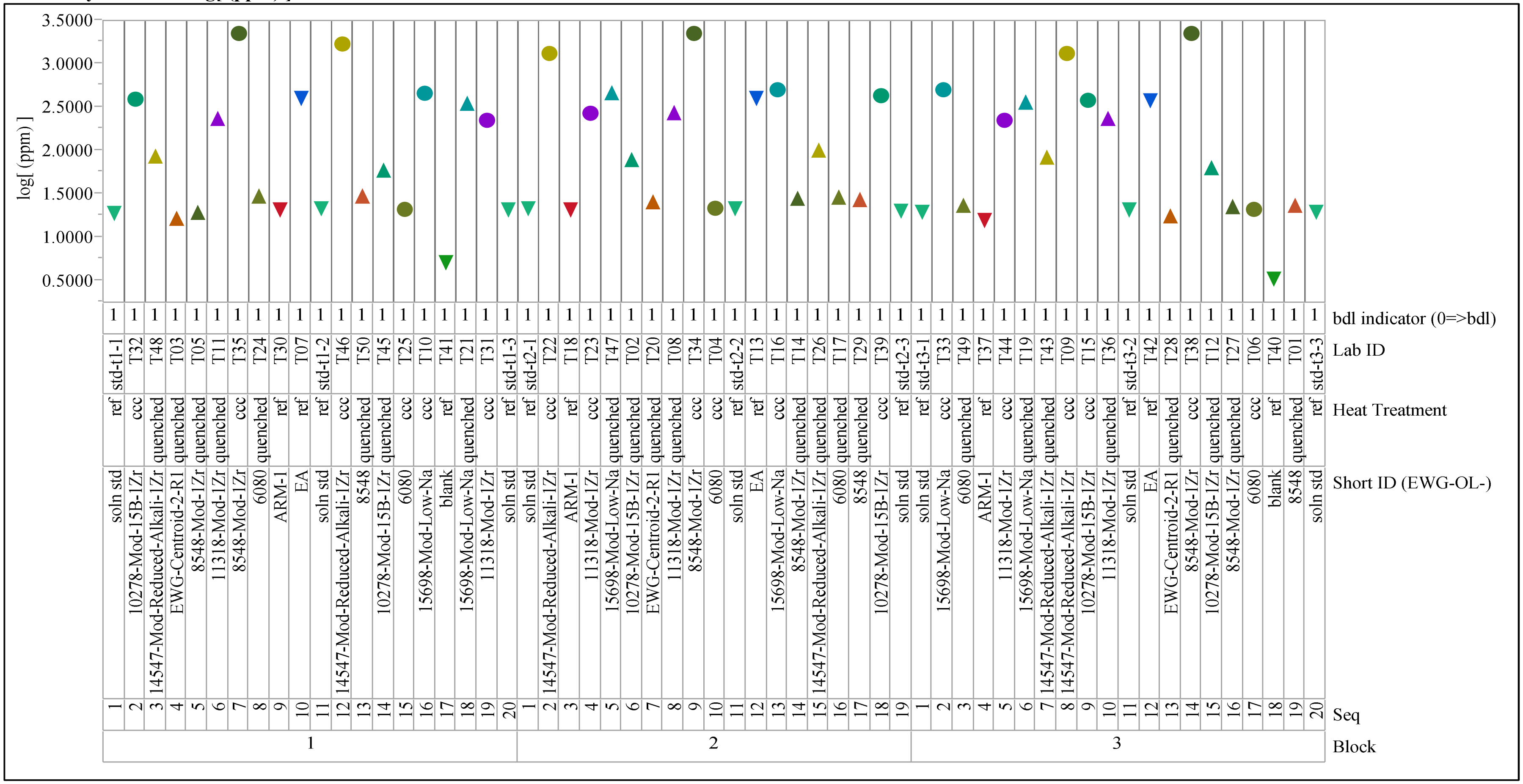


Exhibit B-1. PCT Measurements in Analytical Sequence by Analytical Set (continued)

Set=2, Analyte=log[Ca ppm]
Variability Chart for log[(ppm)]

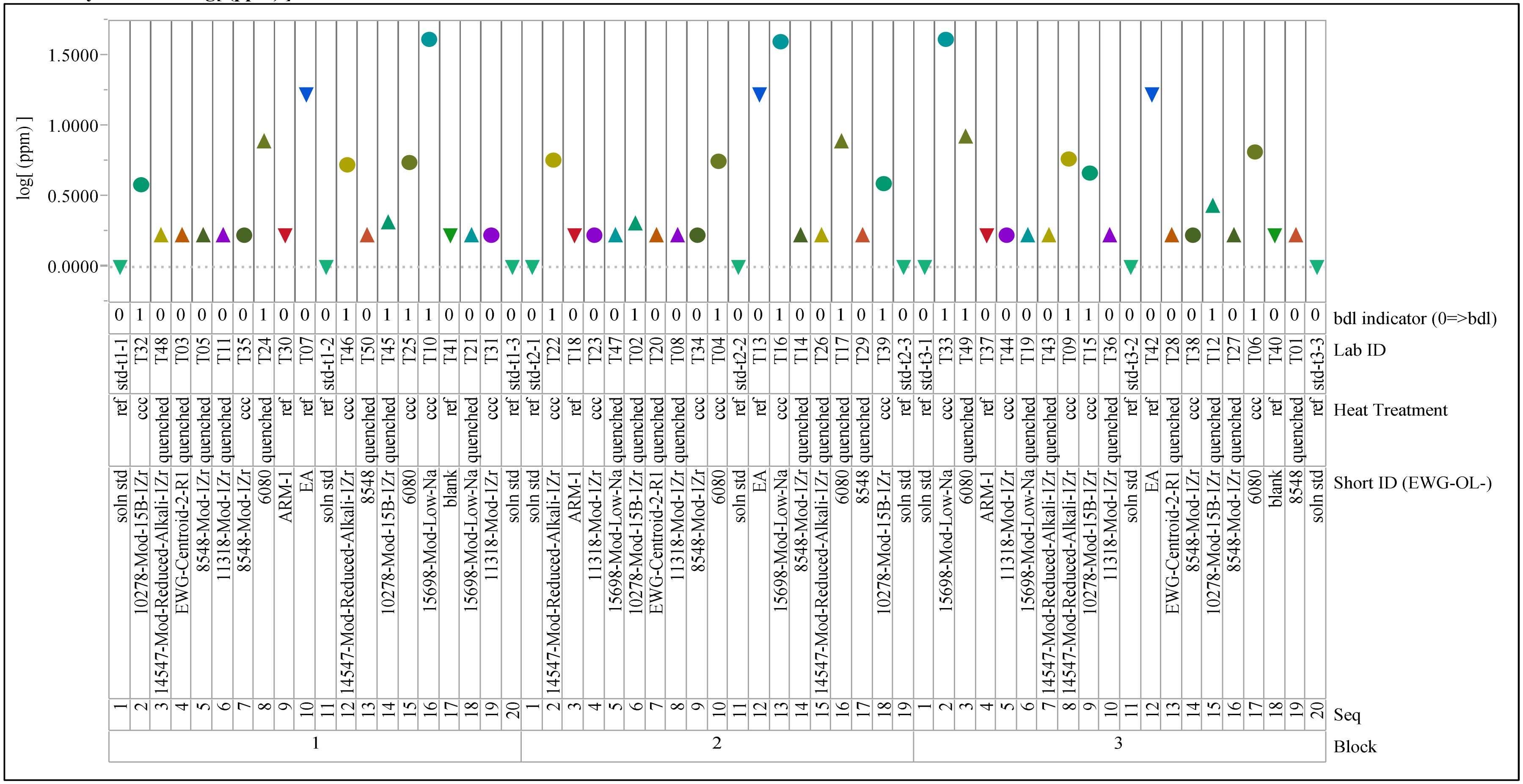


Exhibit B-1. PCT Measurements in Analytical Sequence by Analytical Set (continued)

Set=2, Analyte=log[K ppm]
Variability Chart for log[(ppm)]

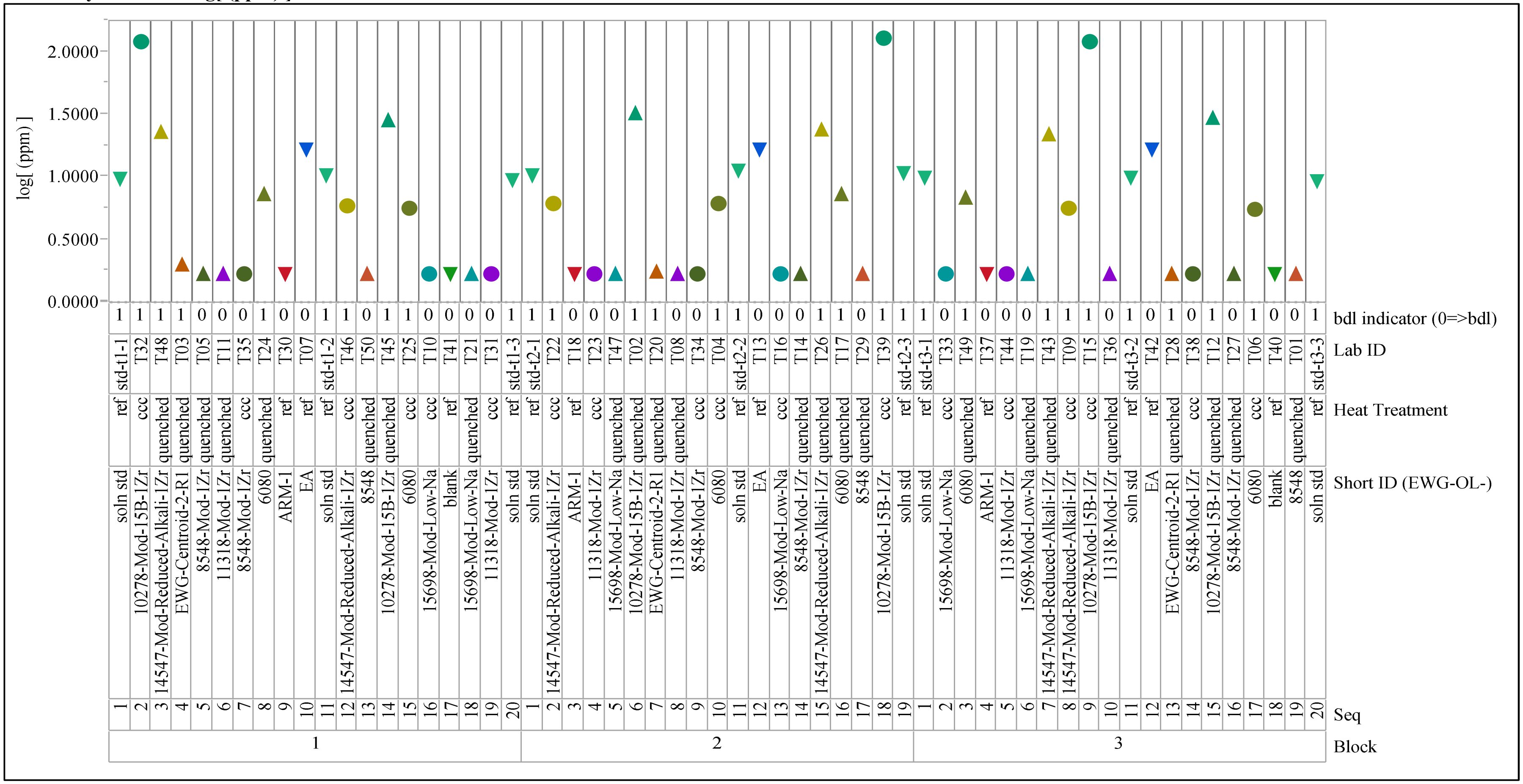


Exhibit B-1. PCT Measurements in Analytical Sequence by Analytical Set (continued)

Set=2, Analyte=log[Li ppm]
Variability Chart for log[(ppm)]

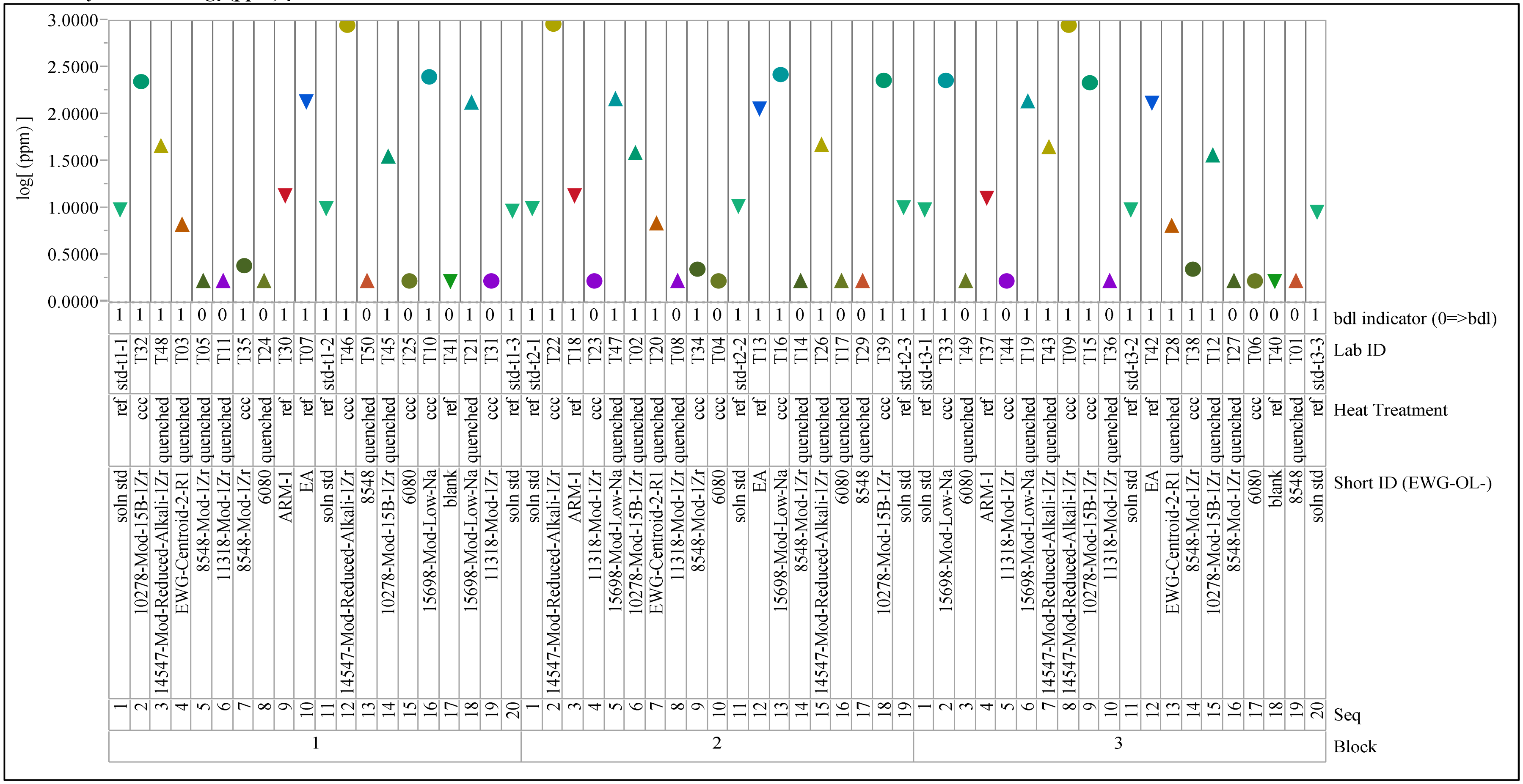


Exhibit B-1. PCT Measurements in Analytical Sequence by Analytical Set (continued)

Set=2, Analyte=log[Na ppm]
Variability Chart for log[(ppm)]

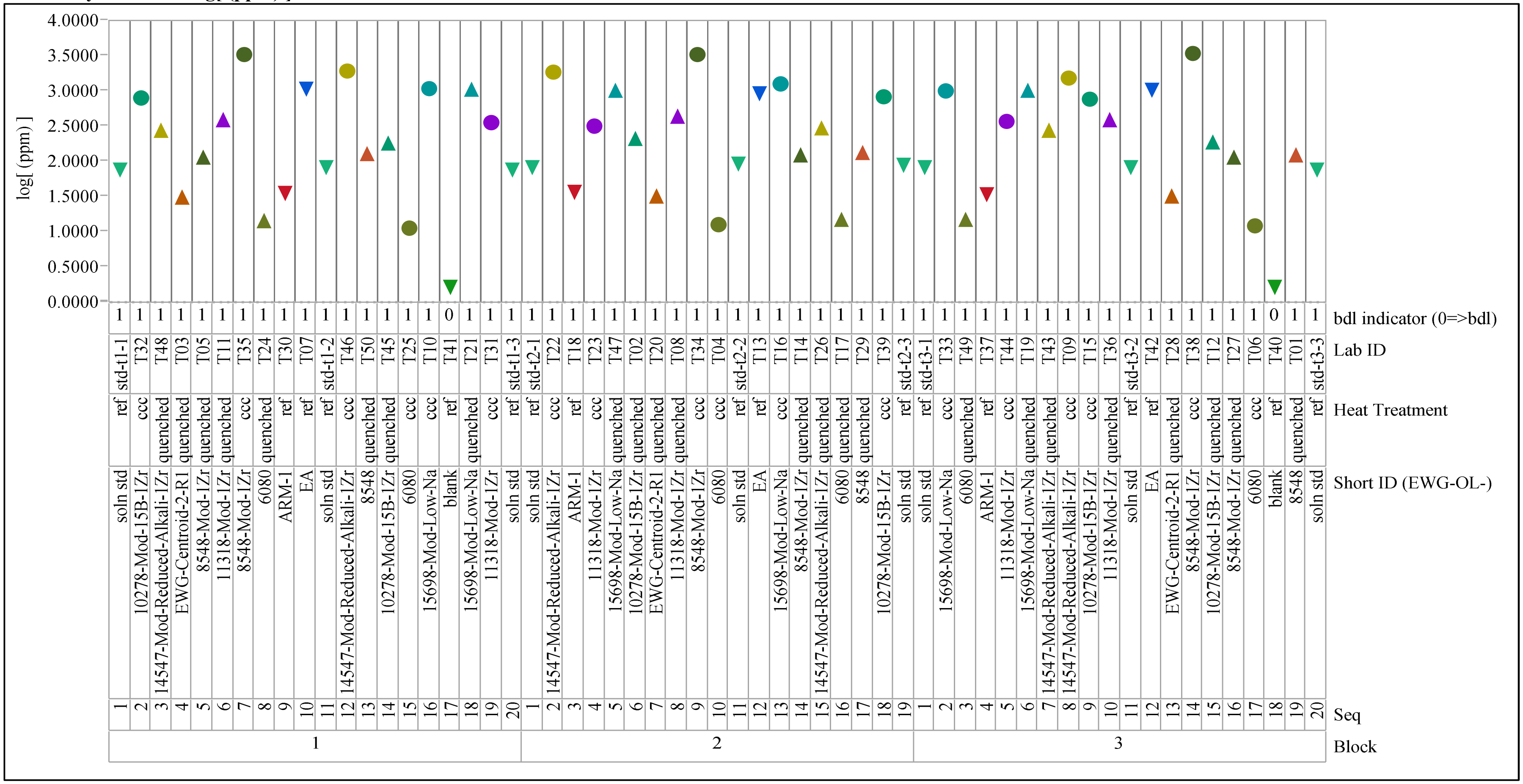


Exhibit B-1. PCT Measurements in Analytical Sequence by Analytical Set (continued)

Set=2, Analyte=log[P ppm]
Variability Chart for log[(ppm)]

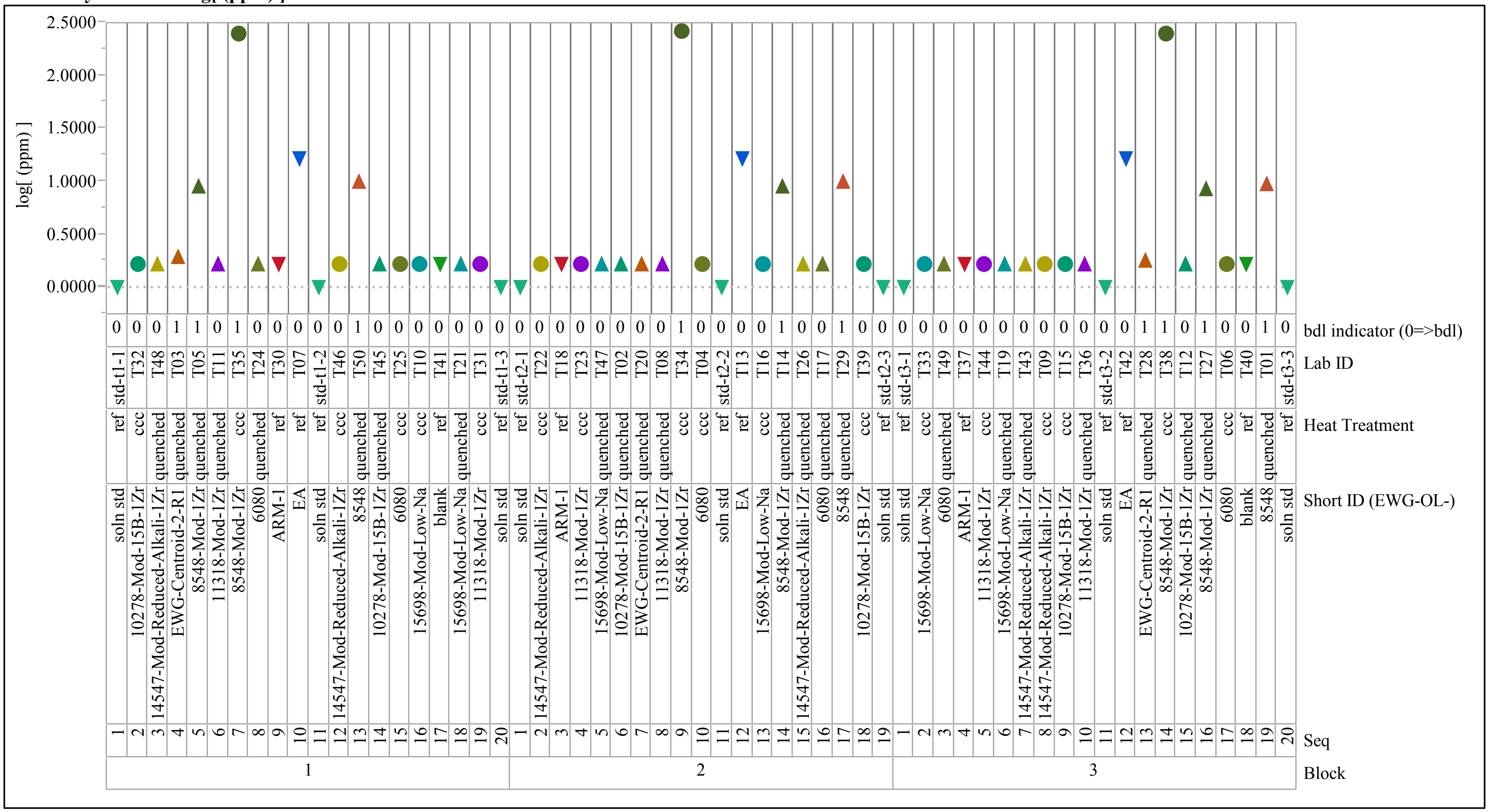


Exhibit B-1. PCT Measurements in Analytical Sequence by Analytical Set (continued)

Set=2, Analyte=log[Si ppm]
Variability Chart for log[(ppm)]

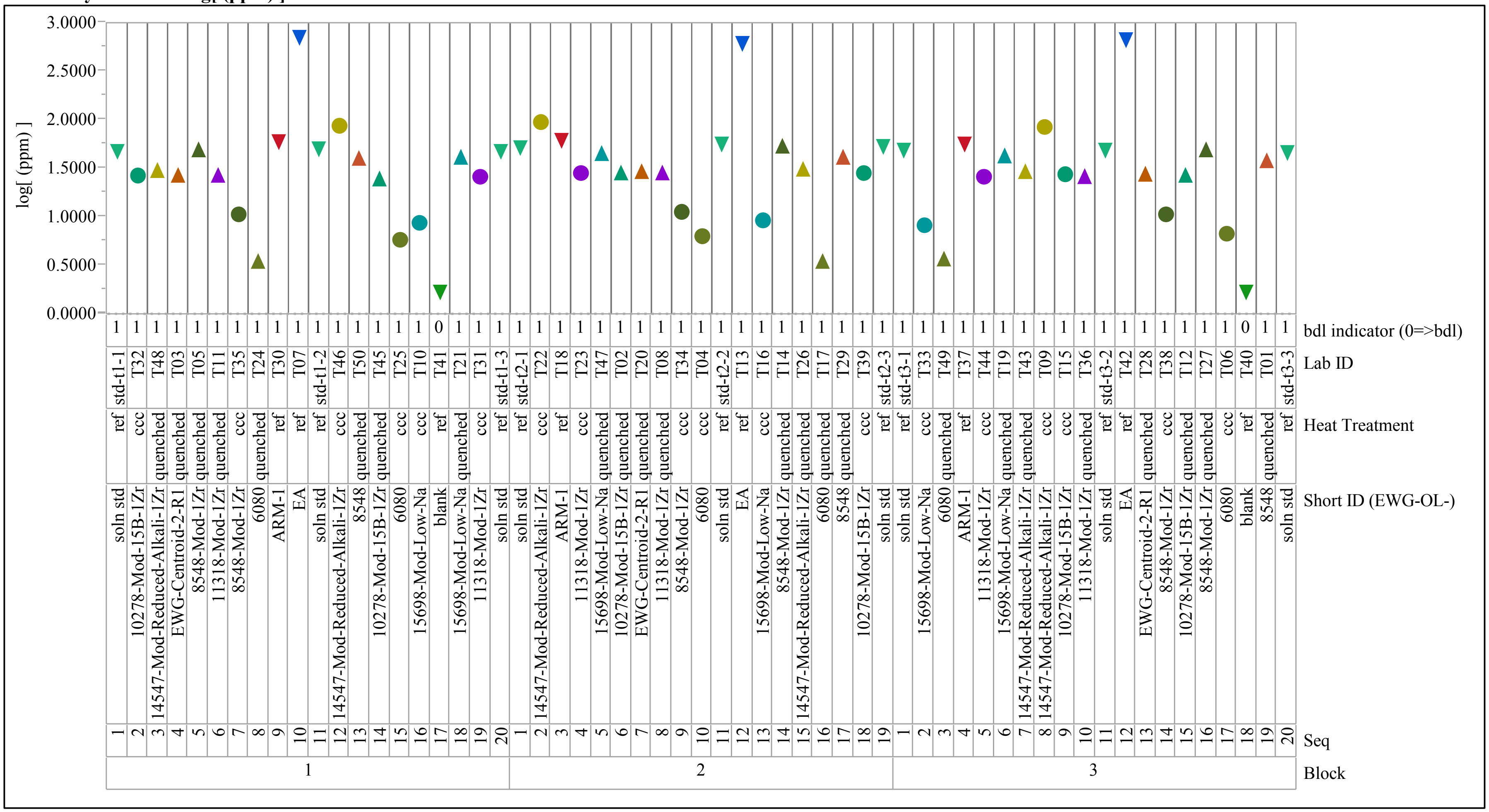


Exhibit B-2. PCT Measurements for Each Set of HLW Set 3 Study Glasses

Set=1, Analyte=log[B ppm]
Variability Chart for log[(ppm)]

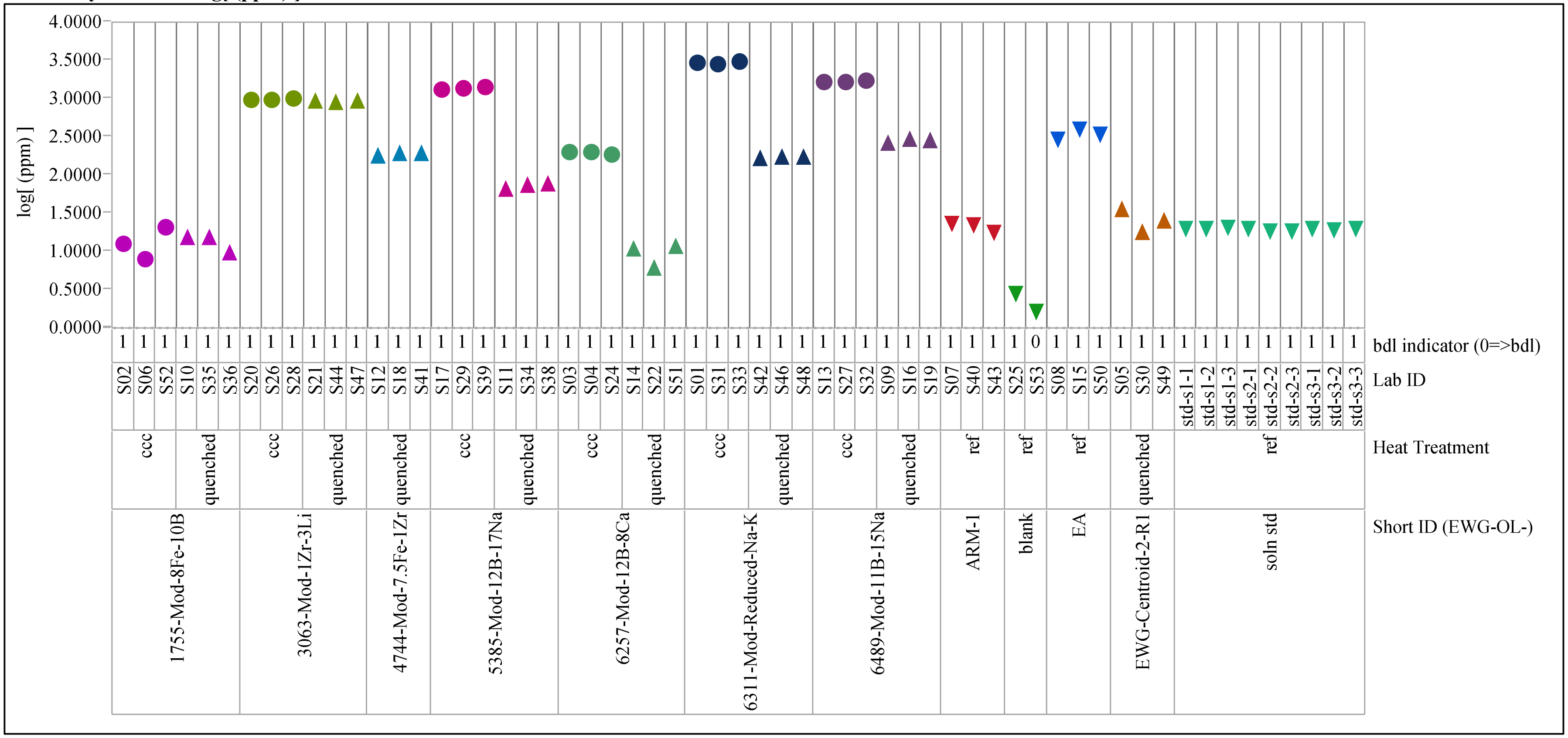


Exhibit B-2. PCT Measurements for Each Set of HLW Set 3 Study Glasses (continued)

Set=1, Analyte=log[Ca ppm]
Variability Chart for log[(ppm)]

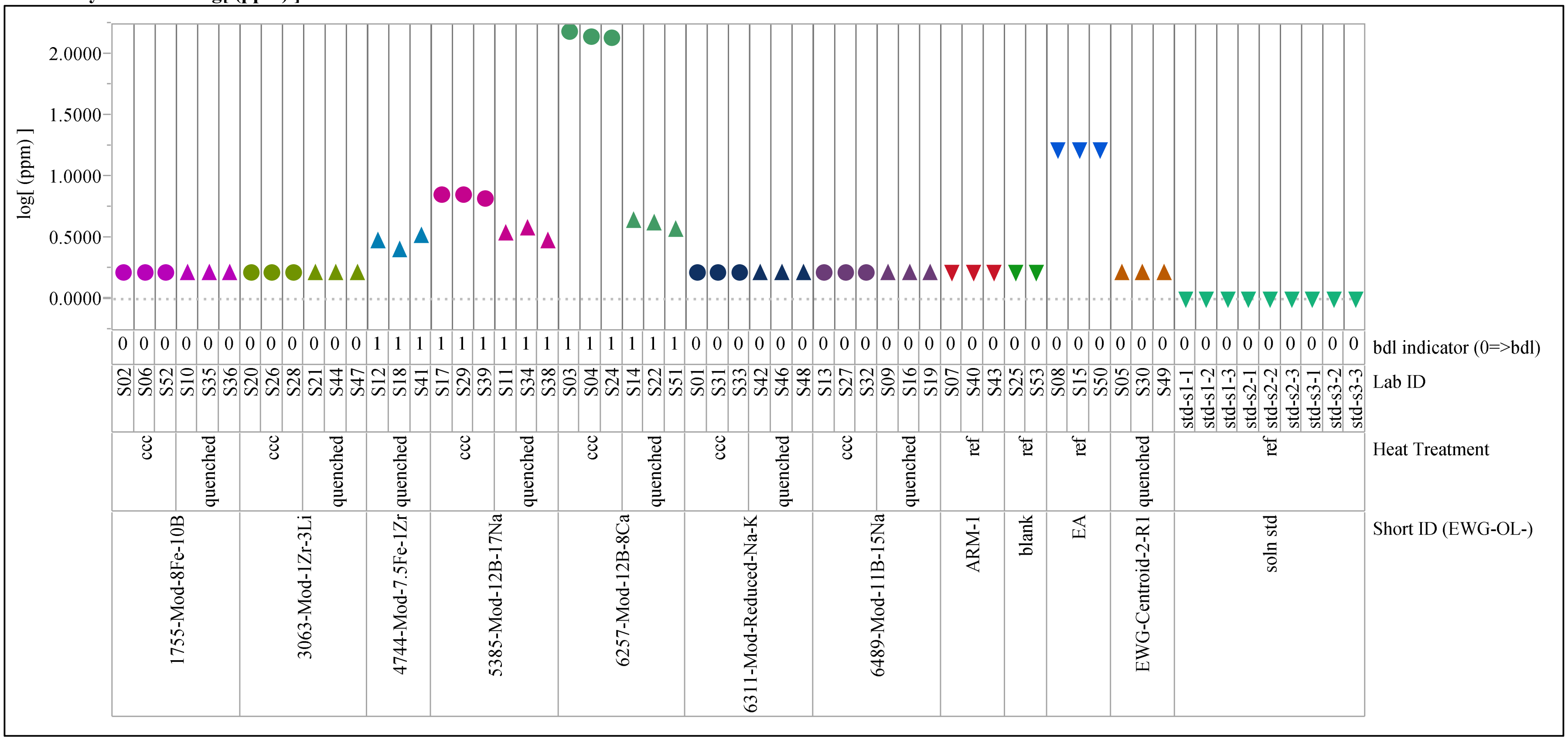


Exhibit B-2. PCT Measurements for Each Set of HLW Set 3 Study Glasses (continued)

Set=1, Analyte=log[K ppm]
Variability Chart for log[(ppm)]

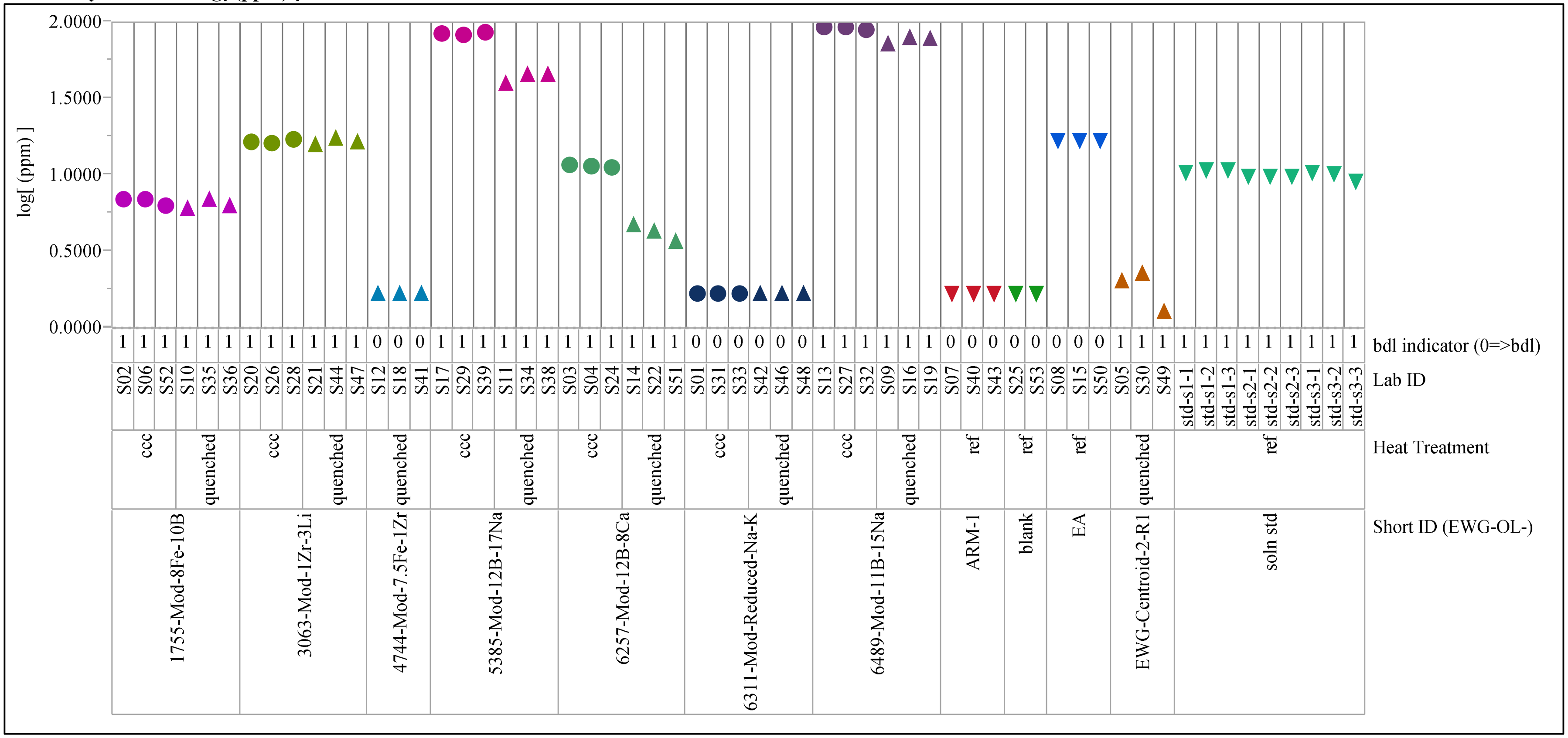


Exhibit B-2. PCT Measurements for Each Set of HLW Set 3 Study Glasses (continued)

Set=1, Analyte=log[Li ppm]
Variability Chart for log[(ppm)]

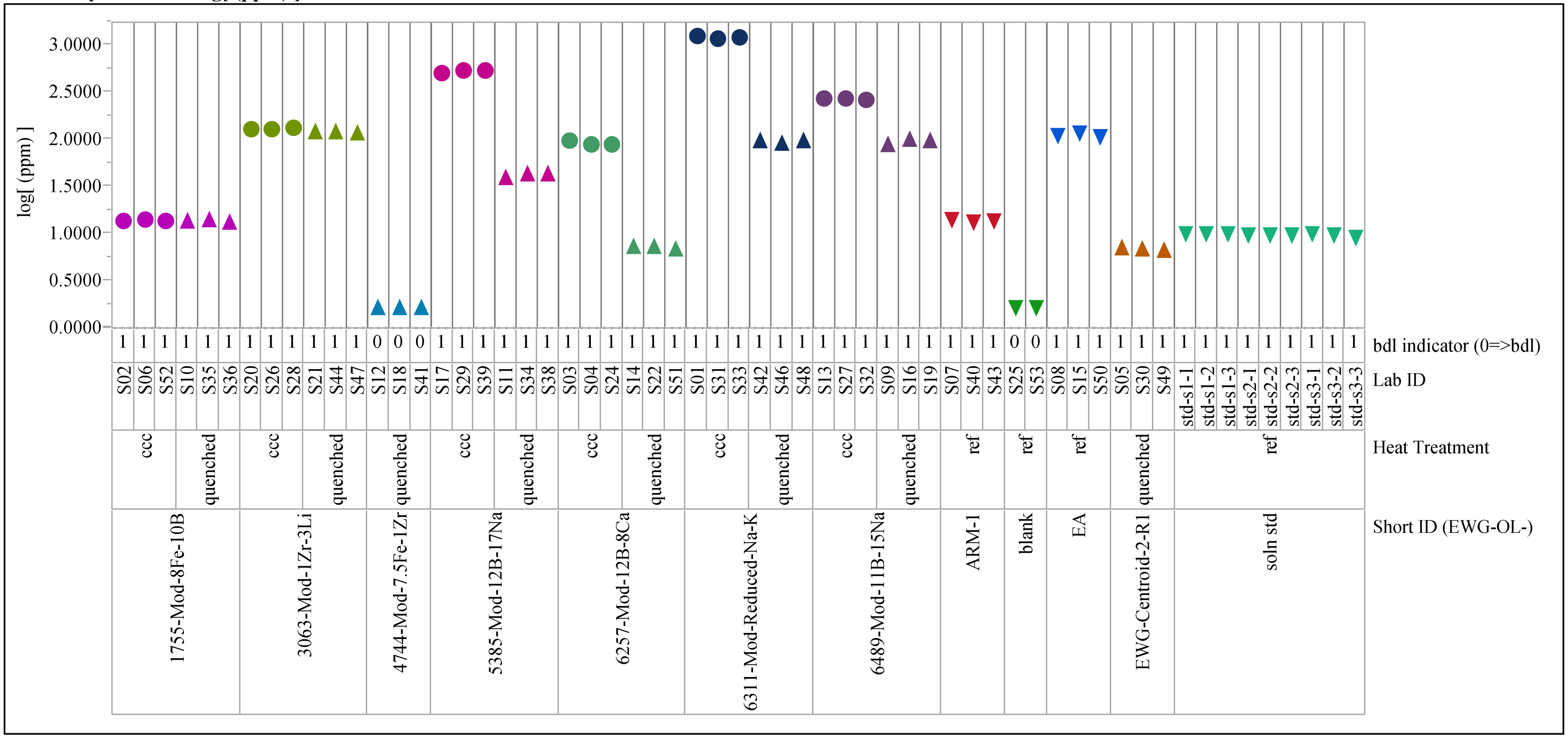


Exhibit B-2. PCT Measurements for Each Set of HLW Set 3 Study Glasses (continued)

Set=1, Analyte=log[Na ppm]
Variability Chart for log[(ppm)]

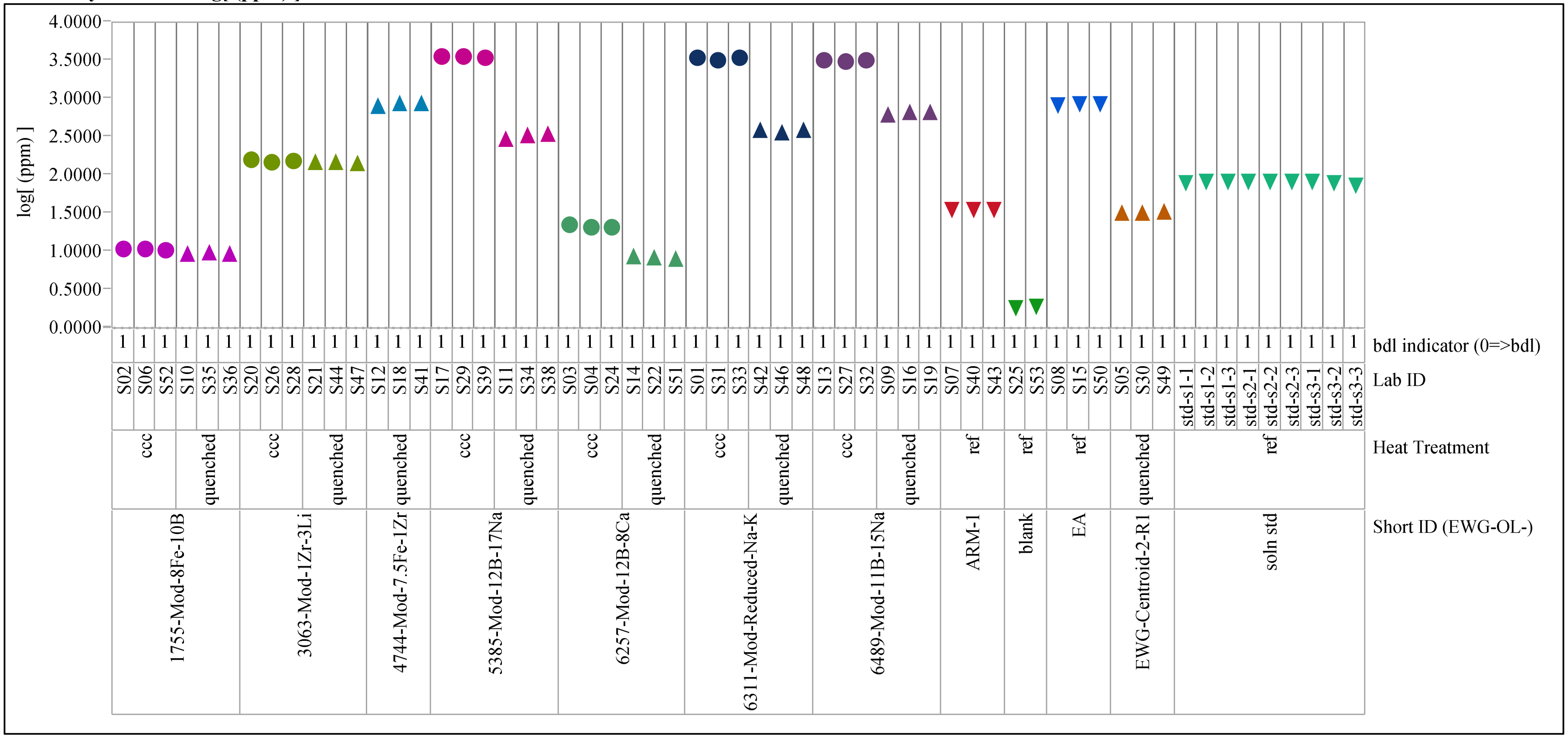


Exhibit B-2. PCT Measurements for Each Set of HLW Set 3 Study Glasses (continued)

Set=1, Analyte=log[P ppm]
Variability Chart for log[(ppm)]

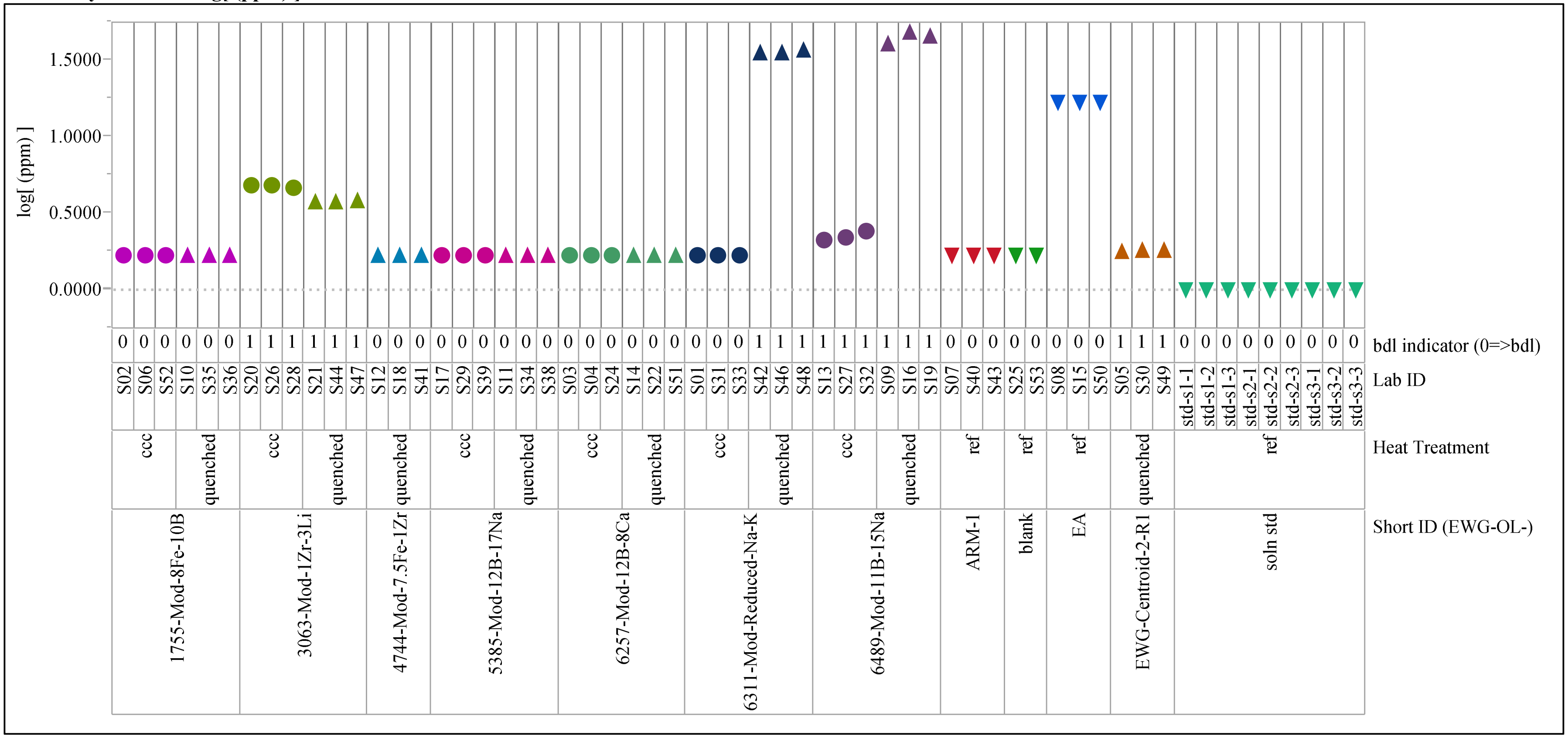


Exhibit B-2. PCT Measurements for Each Set of HLW Set 3 Study Glasses (continued)

Set=1, Analyte=log[Si ppm]
Variability Chart for log[(ppm)]

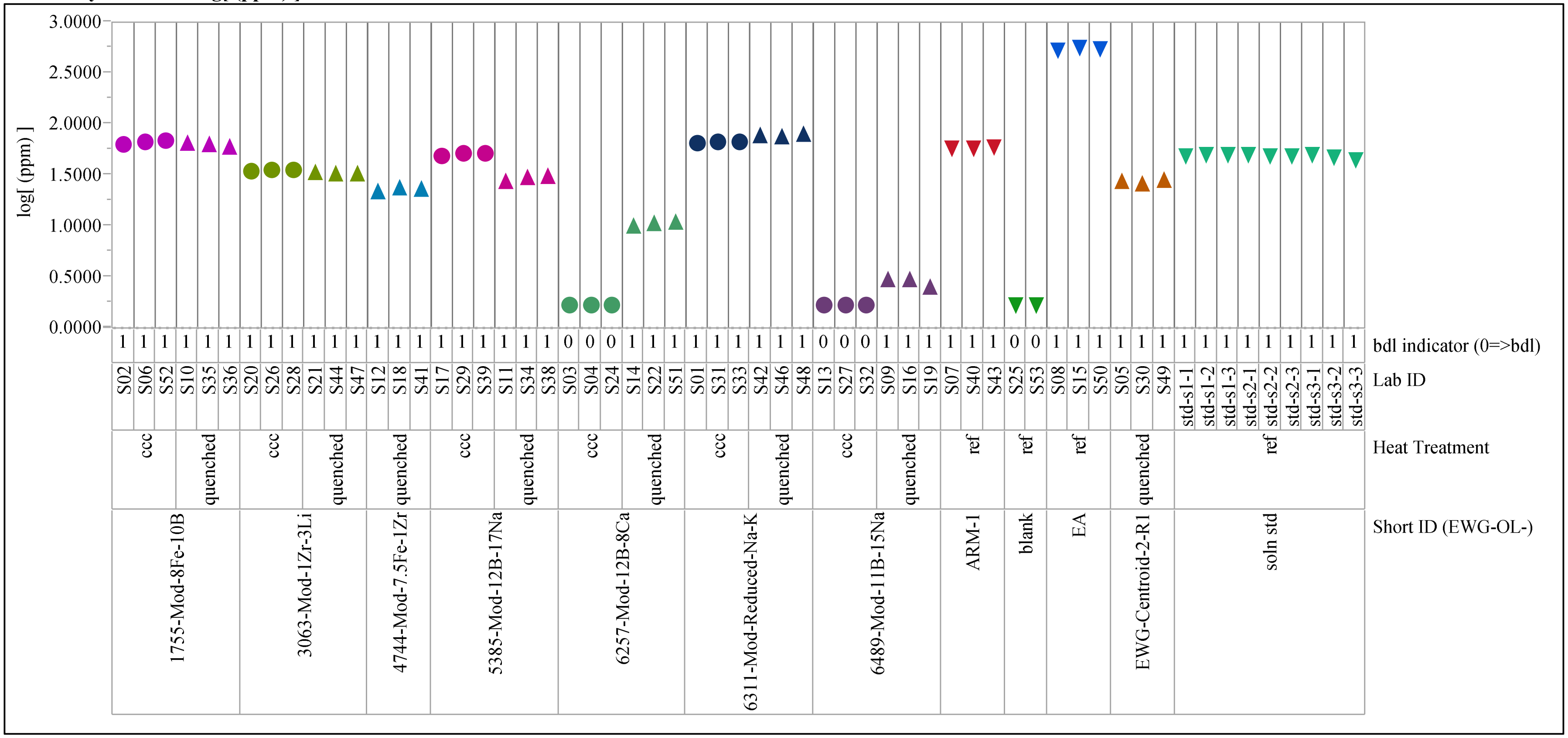


Exhibit B-2. PCT Measurements for Each Set of HLW Set 3 Study Glasses (continued)

Set=2, Analyte=log[B ppm]
Variability Chart for log[(ppm)]

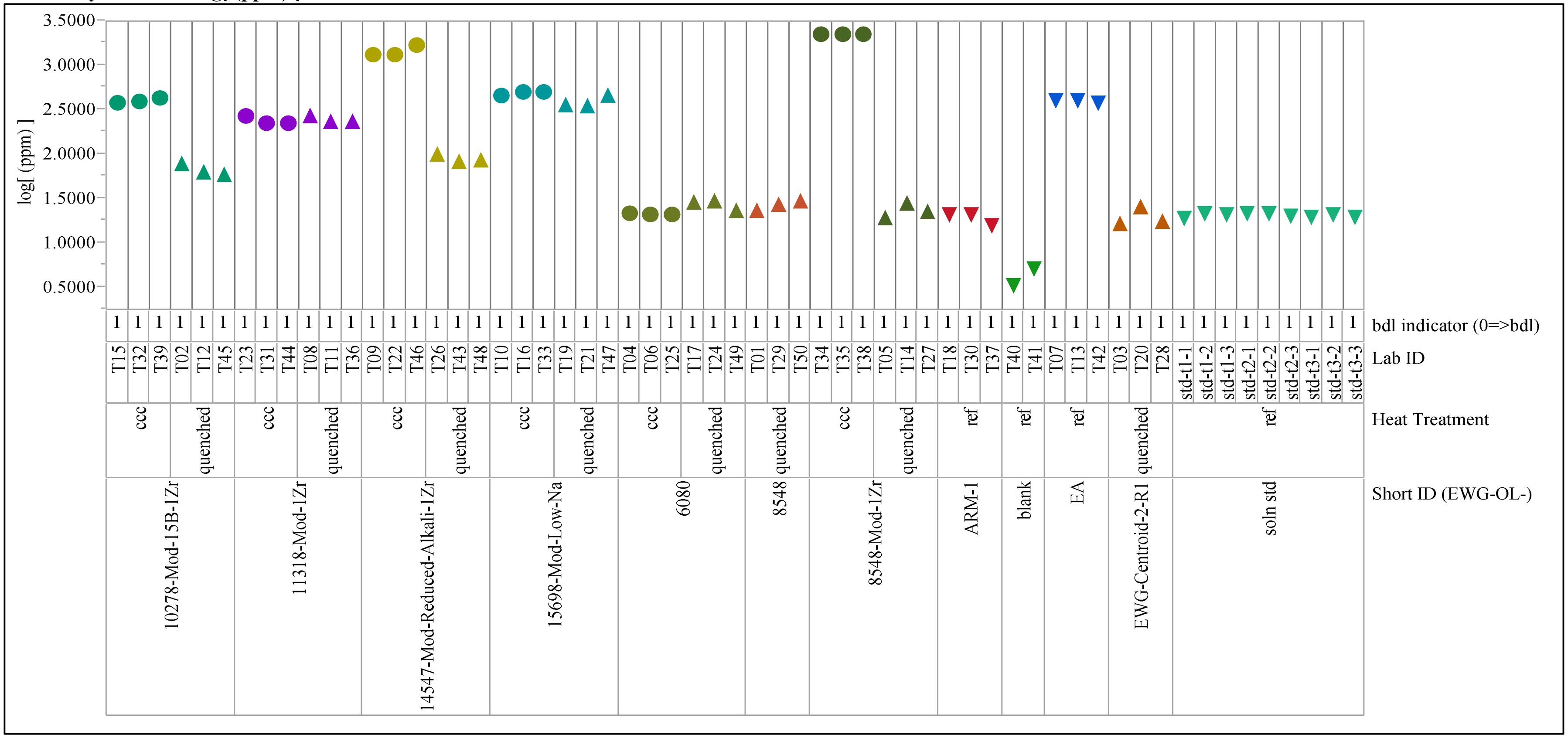


Exhibit B-2. PCT Measurements for Each Set of HLW Set 3 Study Glasses (continued)

Set=2, Analyte=log[Ca ppm]
Variability Chart for log[(ppm)]

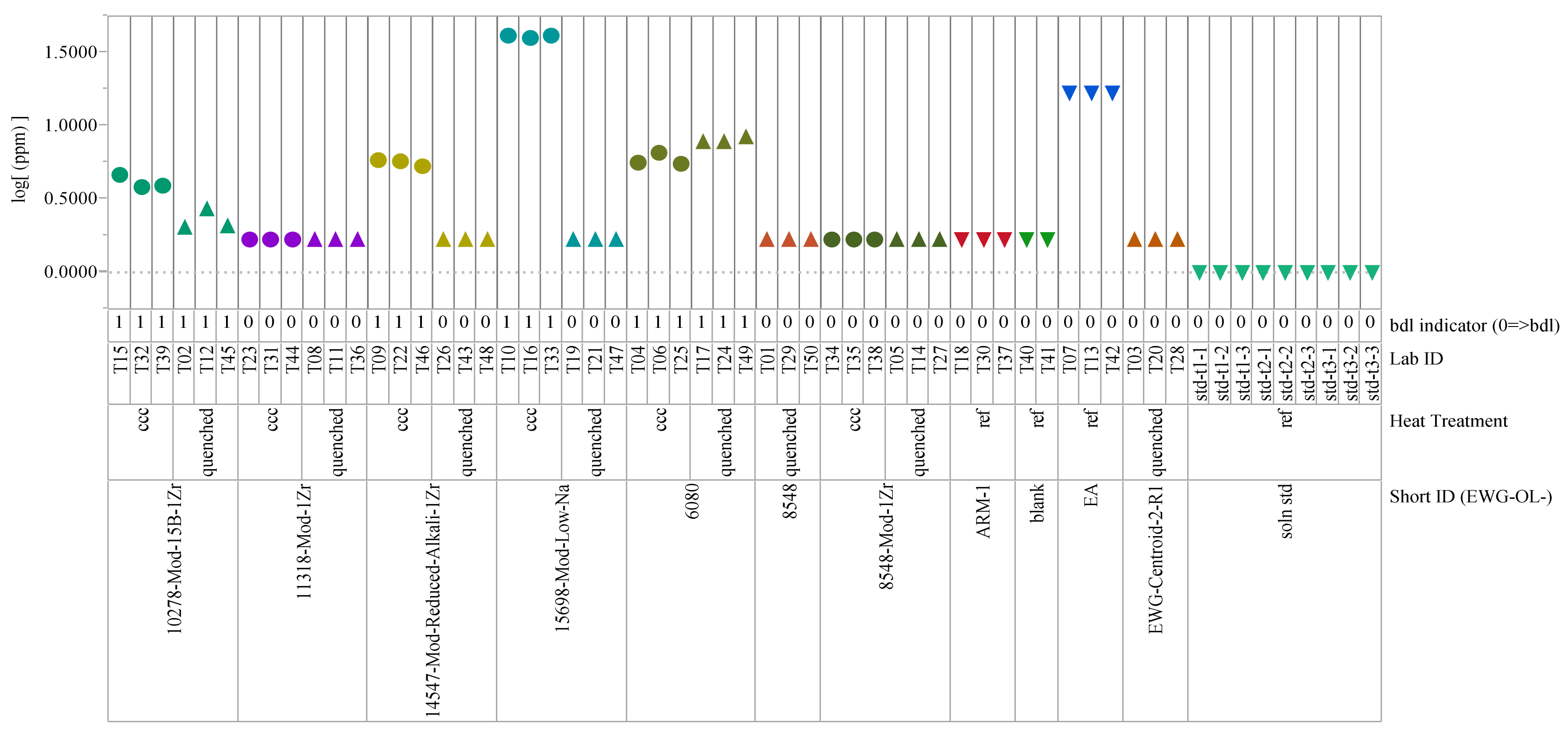


Exhibit B-2. PCT Measurements for Each Set of HLW Set 3 Study Glasses (continued)

Set=2, Analyte=log[K ppm]
Variability Chart for log[(ppm)]

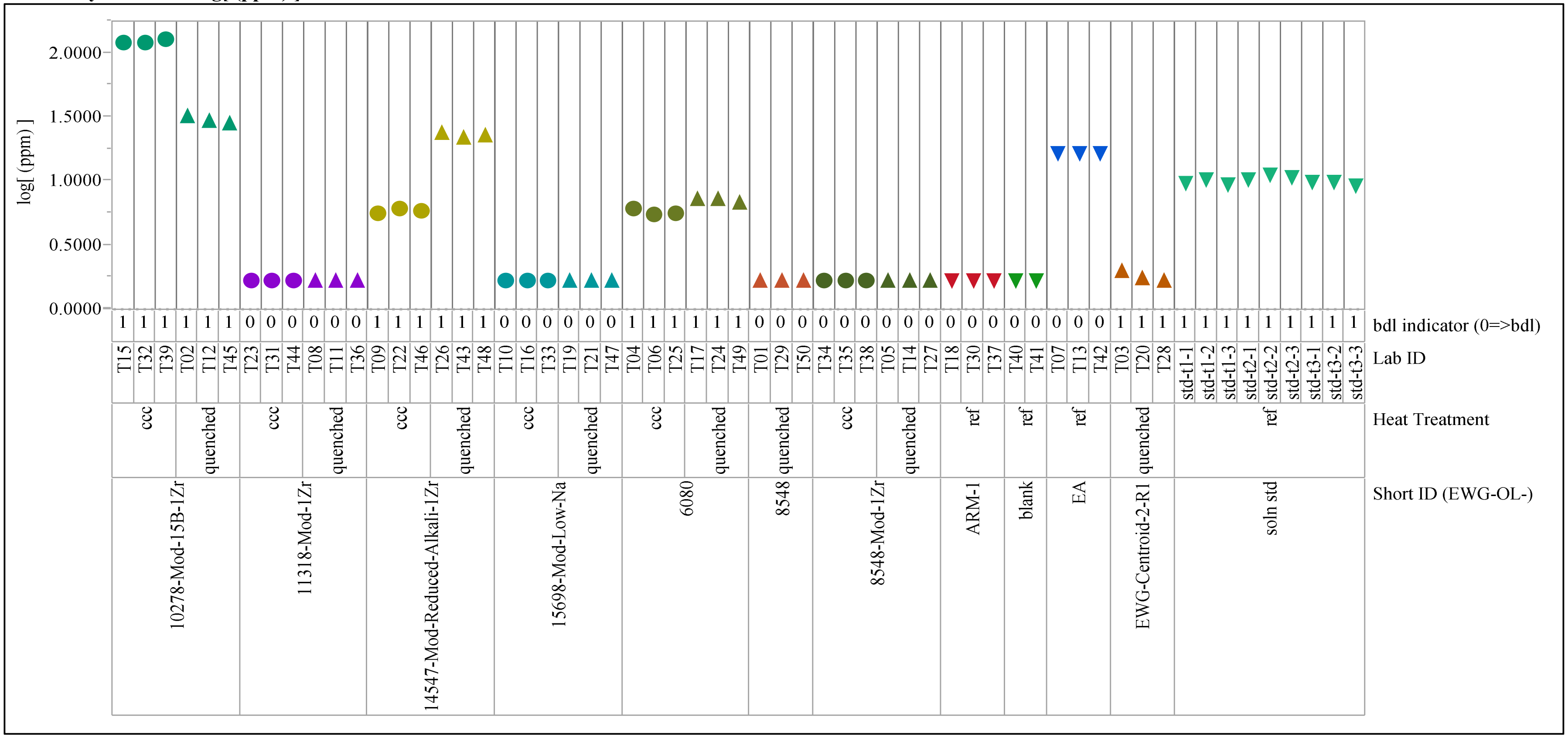


Exhibit B-2. PCT Measurements for Each Set of HLW Set 3 Study Glasses (continued)

Set=2, Analyte=log[Li ppm]
Variability Chart for log[(ppm)]

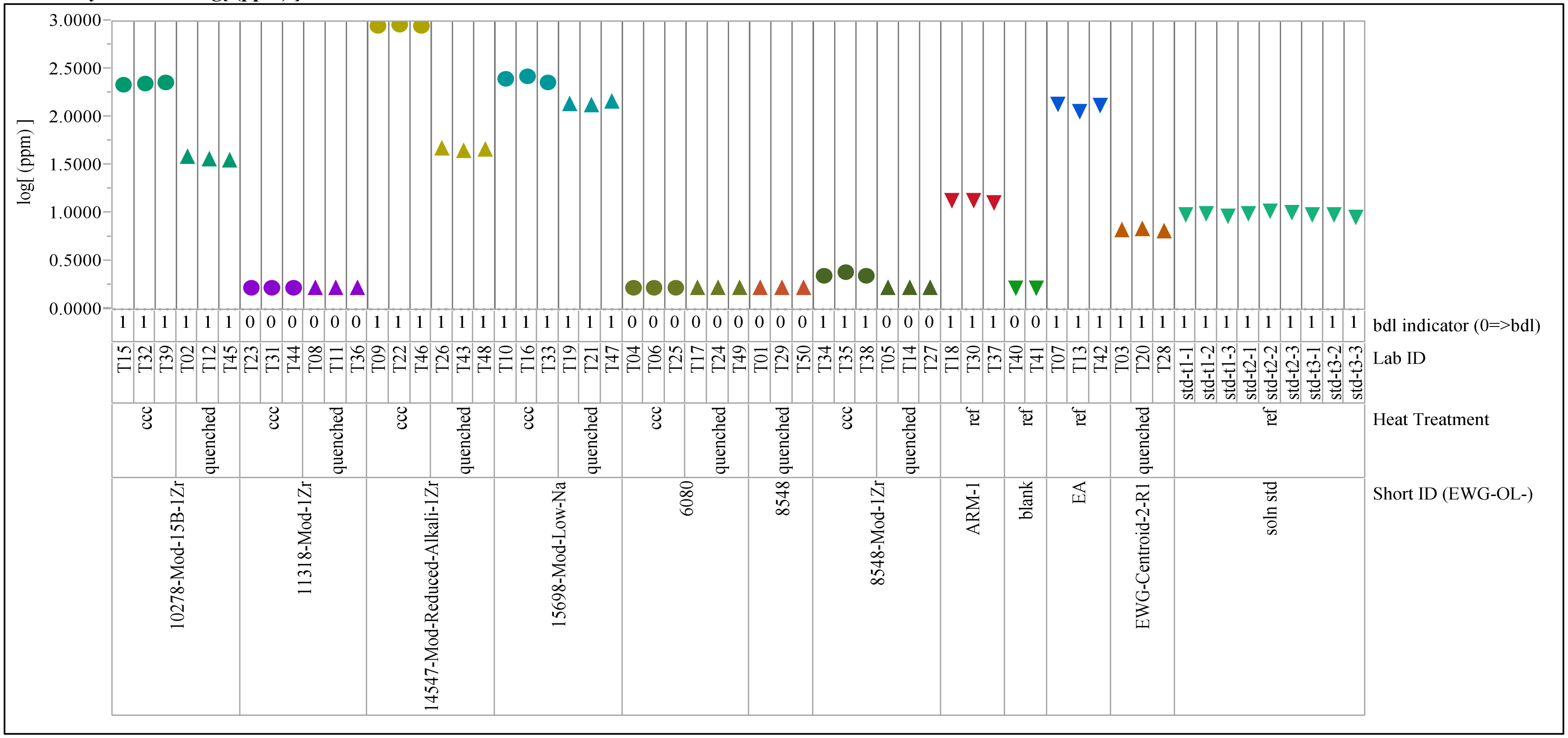


Exhibit B-2. PCT Measurements for Each Set of HLW Set 3 Study Glasses (continued)

Set=2, Analyte=log[Na ppm]
Variability Chart for log[(ppm)]

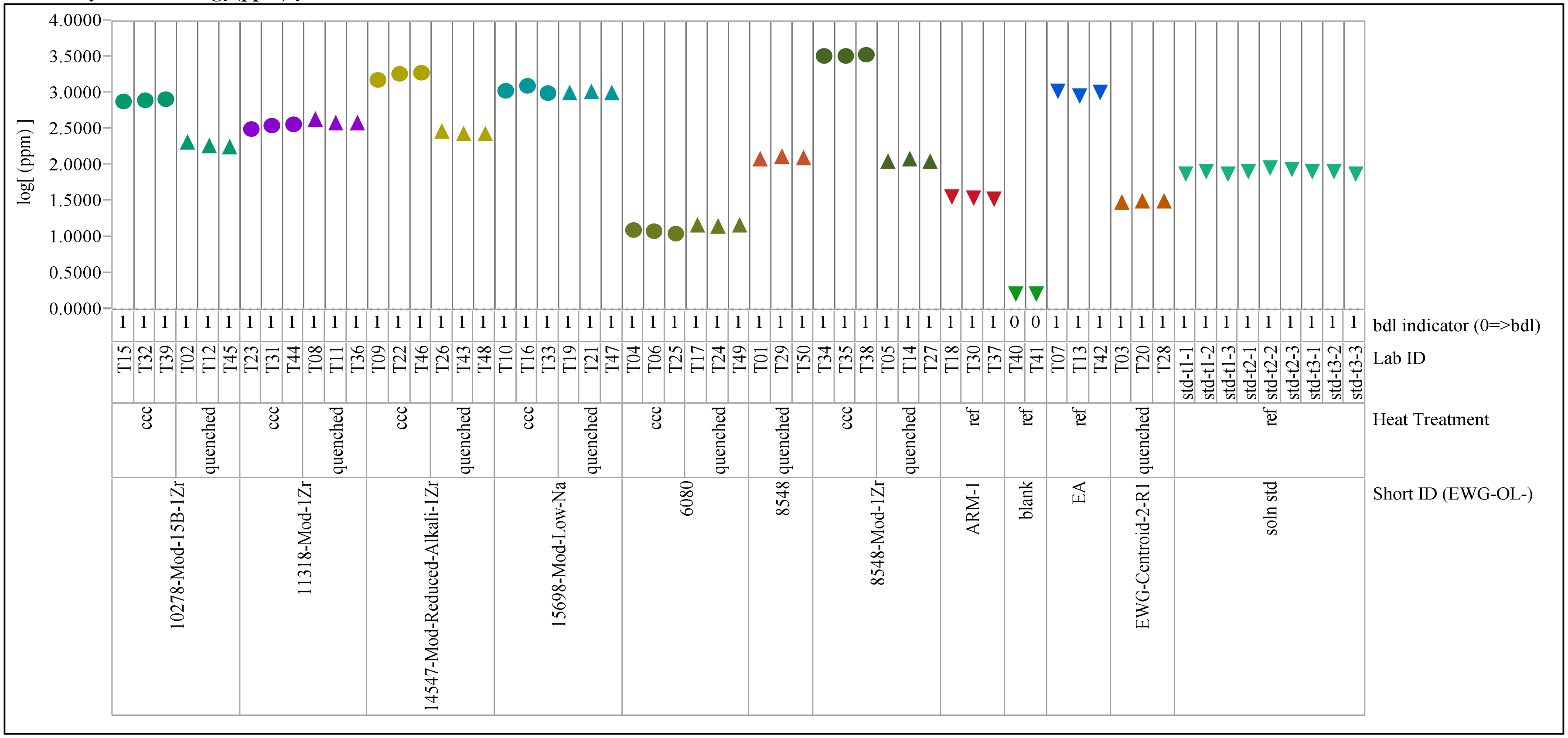


Exhibit B-2. PCT Measurements for Each Set of HLW Set 3 Study Glasses (continued)

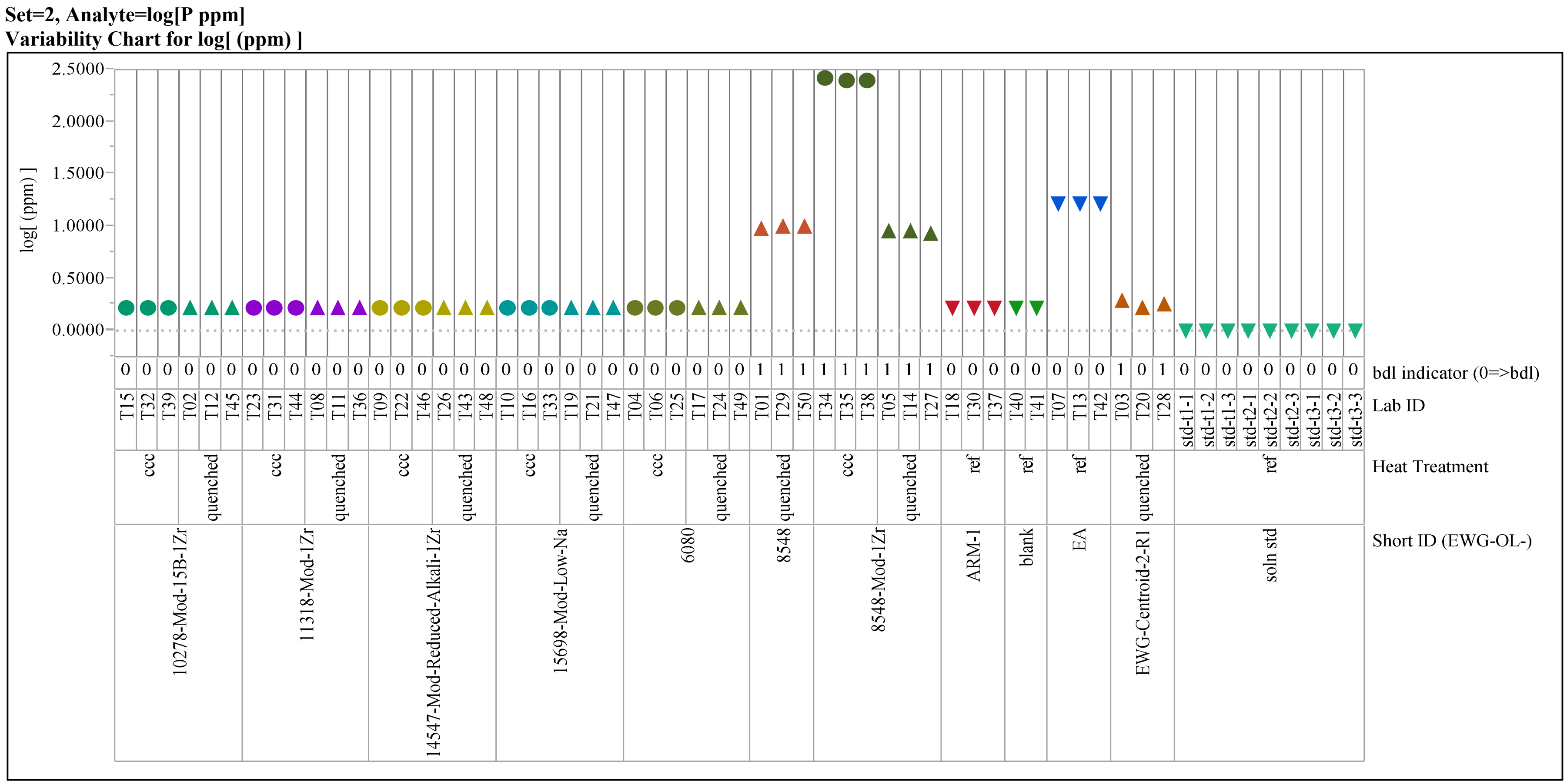


Exhibit B-2. PCT Measurements for Each Set of HLW Set 3 Study Glasses (continued)

Set=2, Analyte=log[Si ppm]
Variability Chart for log[(ppm)]

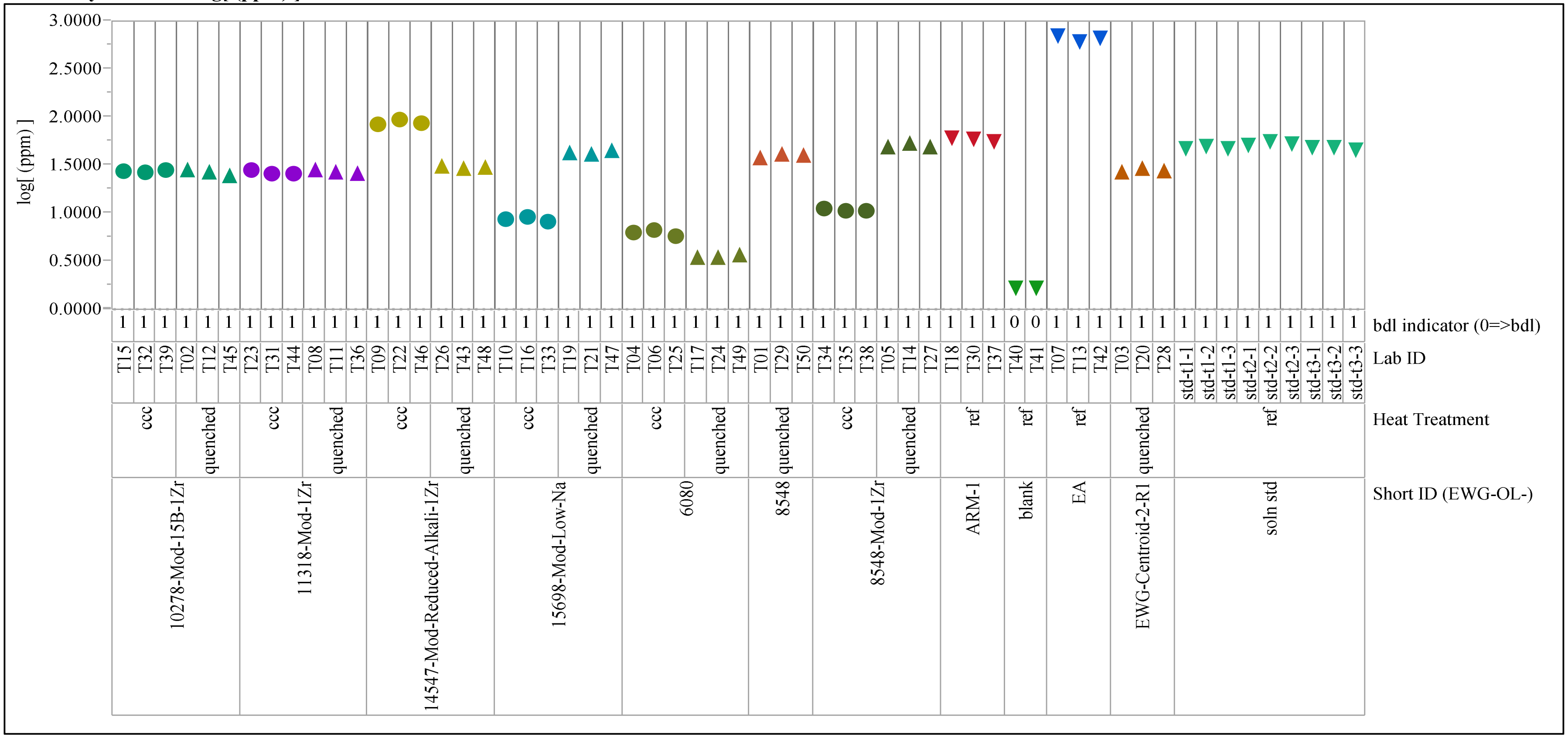


Exhibit B-3. Normalized PCT Results by Heat Treatment by Compositional View for Each Glass

Set=1, Analyte=B
Variability Chart for log NC_B [(g/L)]

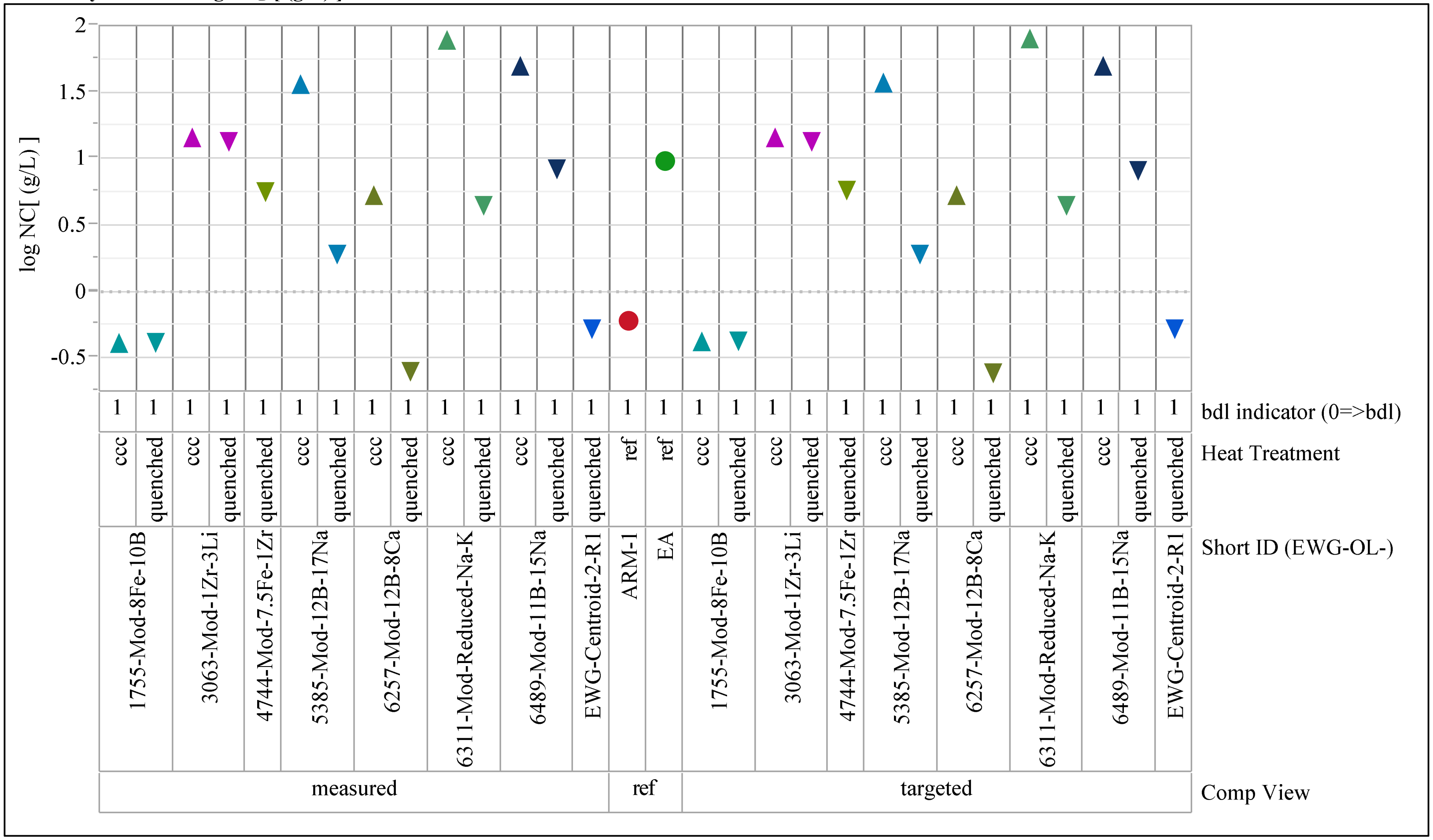


Exhibit B-3. Normalized PCT Results by Heat Treatment by Compositional View for Each Glass (continued)

Set=1, Analyte=Ca
Variability Chart for log NC_{Ca} [(g/L)]

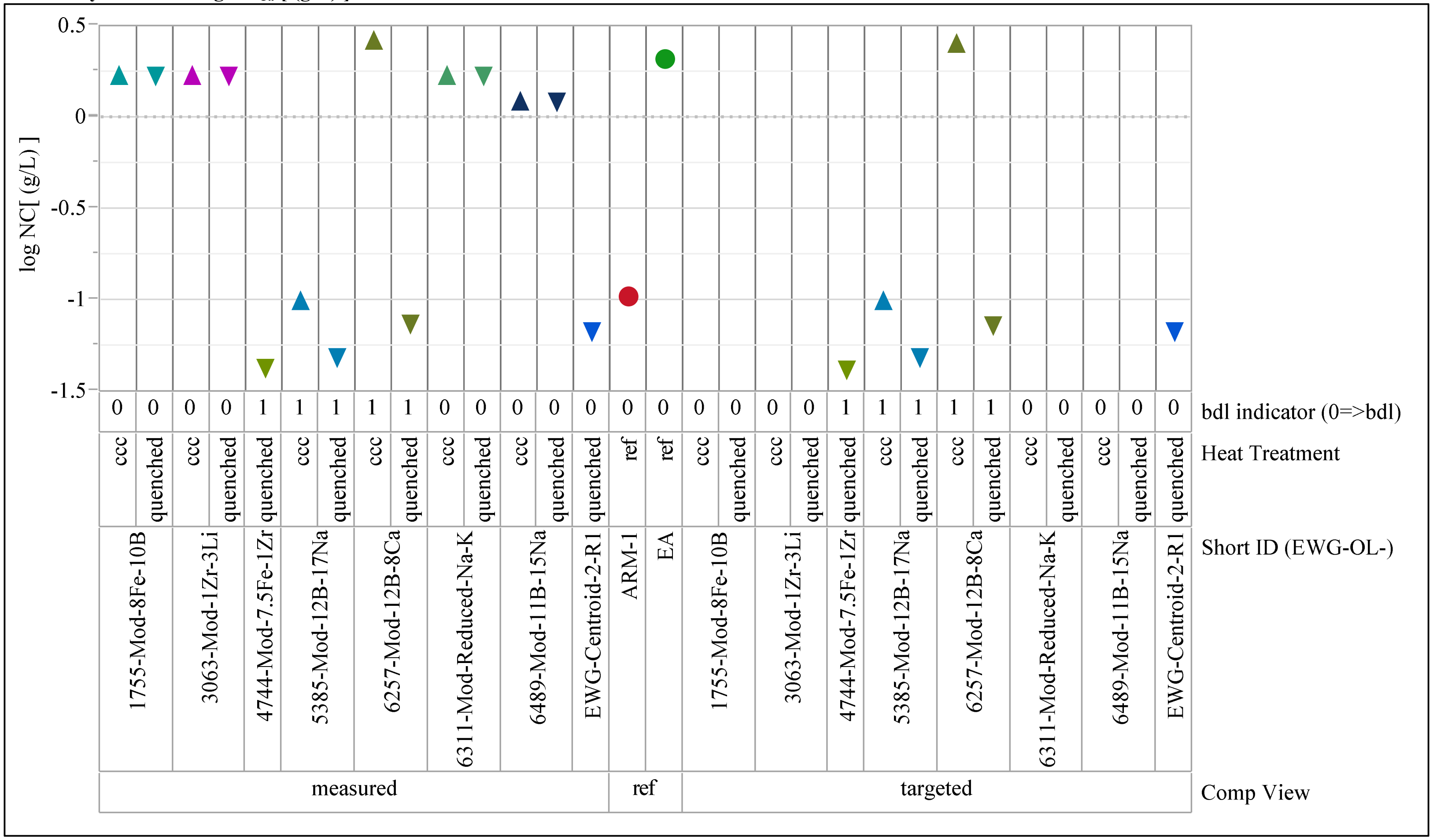


Exhibit B-3. Normalized PCT Results by Heat Treatment by Compositional View for Each Glass (continued)

Set=1, Analyte=K
Variability Chart for log NC_K [(g/L)]

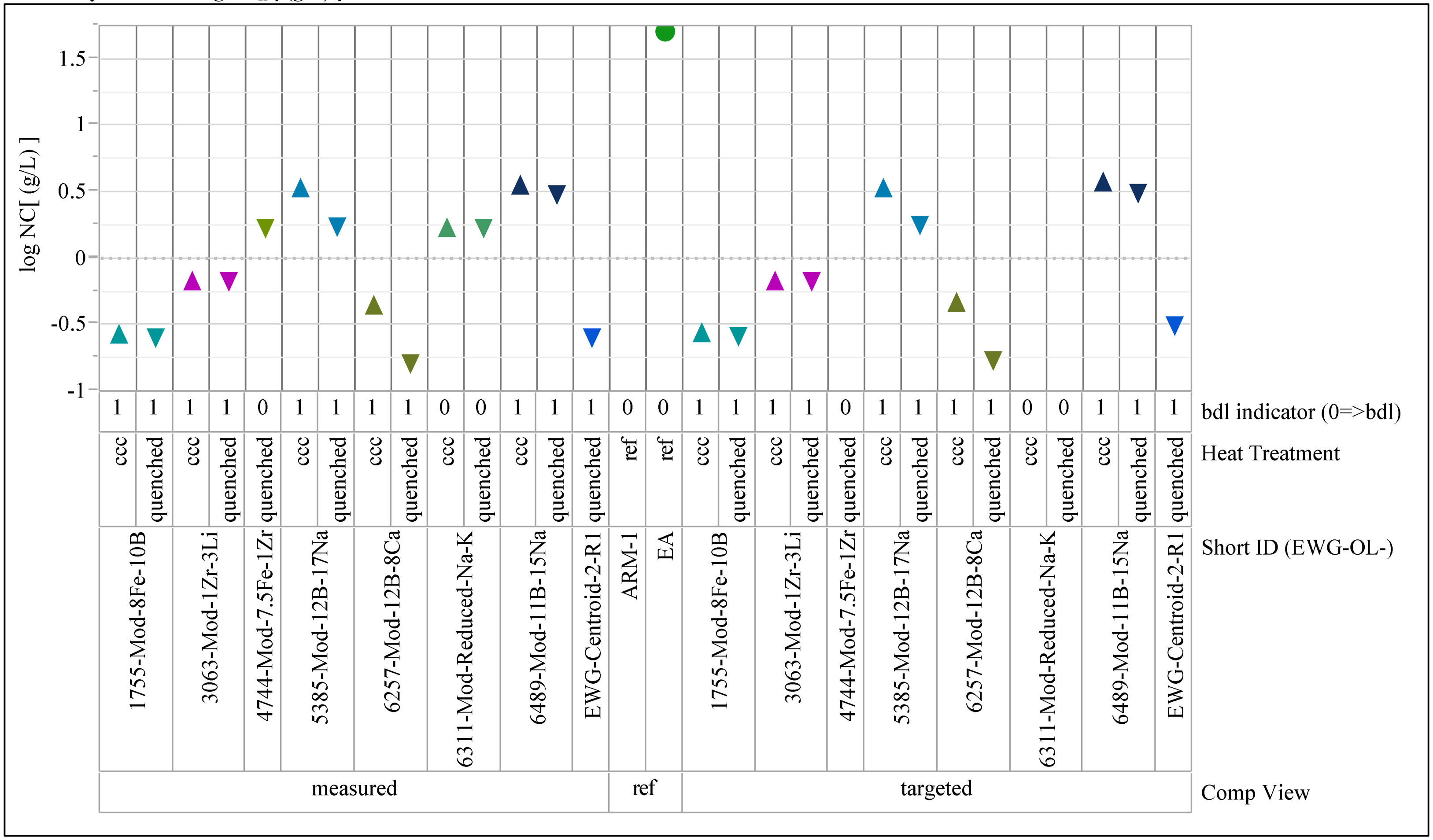


Exhibit B-3. Normalized PCT Results by Heat Treatment by Compositional View for Each Glass (continued)

Set=1, Analyte=Li
Variability Chart for log NC_{Li} [(g/L)]

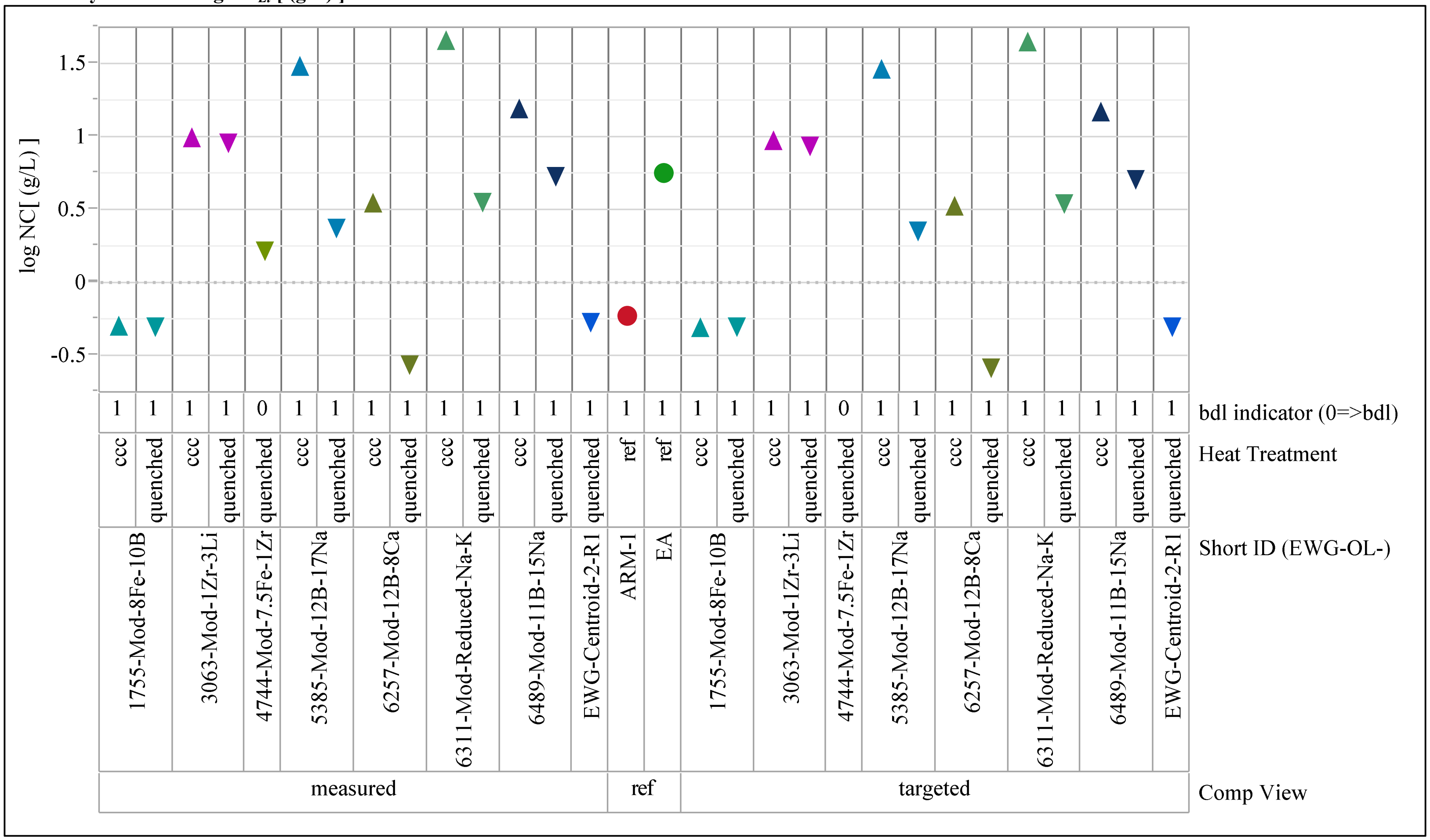


Exhibit B-3. Normalized PCT Results by Heat Treatment by Compositional View for Each Glass (continued)

Set=1, Analyte=Na
Variability Chart for log NC_{Na} [(g/L)]

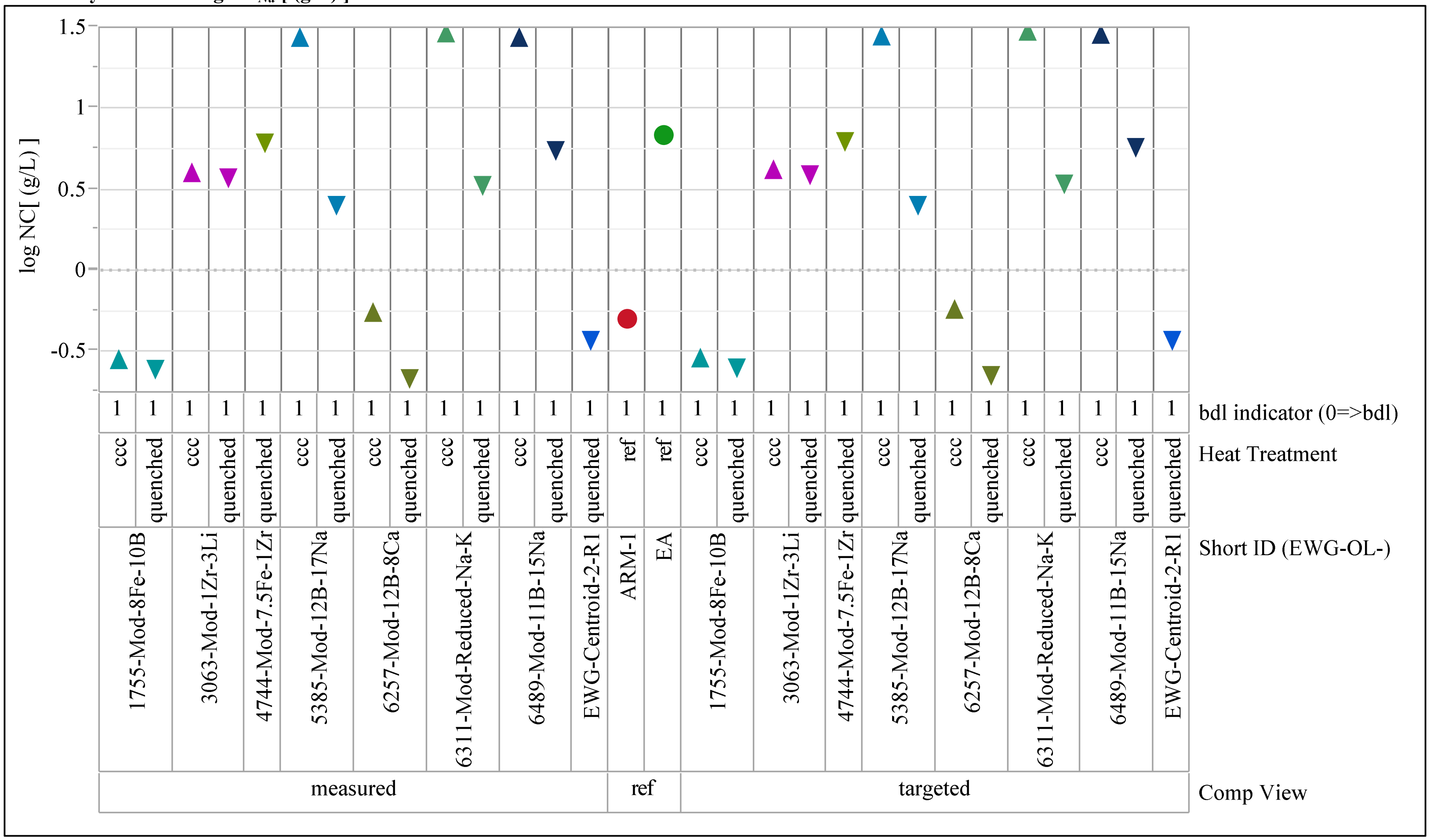


Exhibit B-3. Normalized PCT Results by Heat Treatment by Compositional View for Each Glass (continued)

Set=1, Analyte=P
Variability Chart for log NC_P [(g/L)]

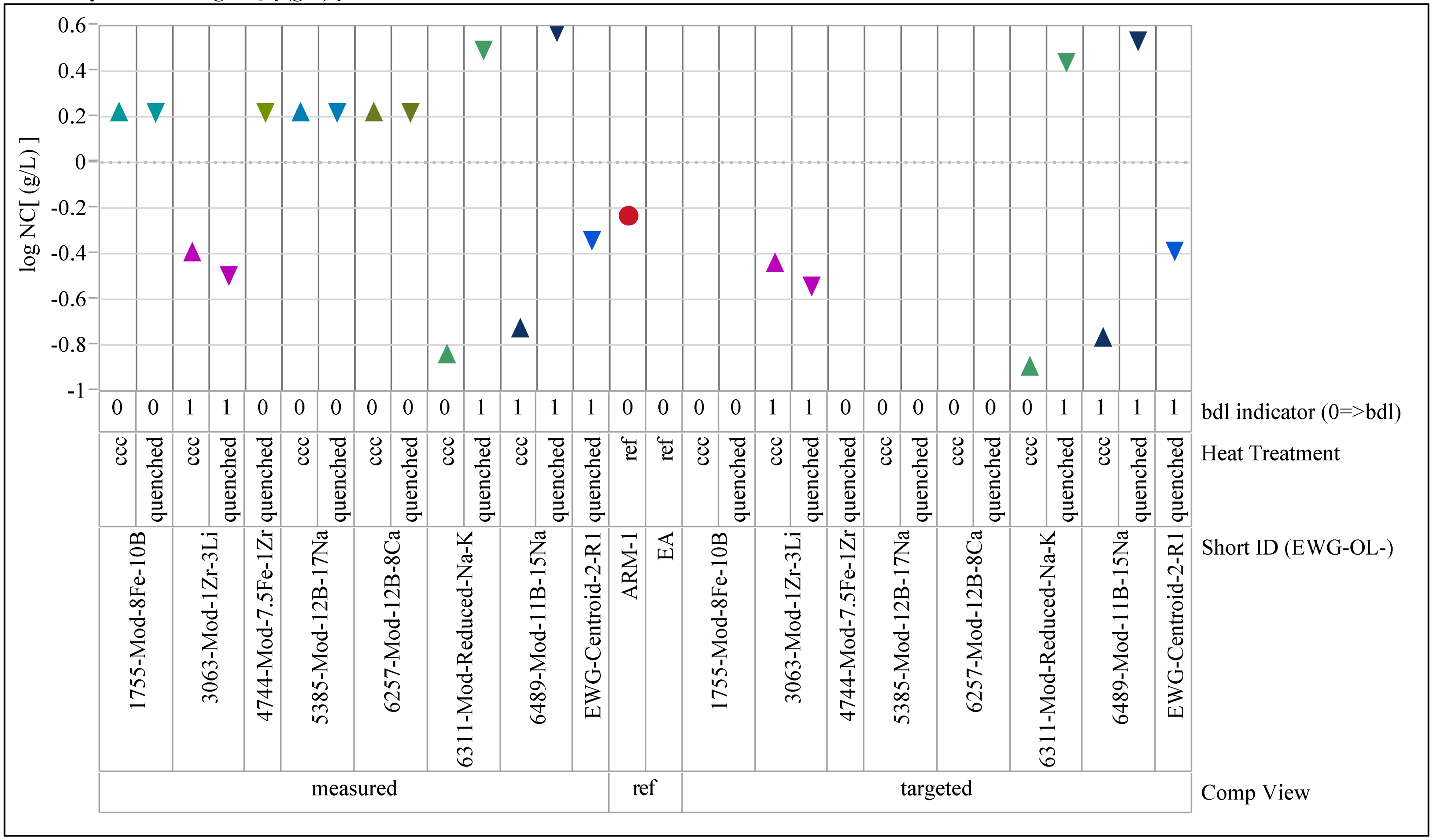


Exhibit B-3. Normalized PCT Results by Heat Treatment by Compositional View for Each Glass (continued)

Set=1, Analyte=Si
Variability Chart for log NC_{Si} [(g/L)]

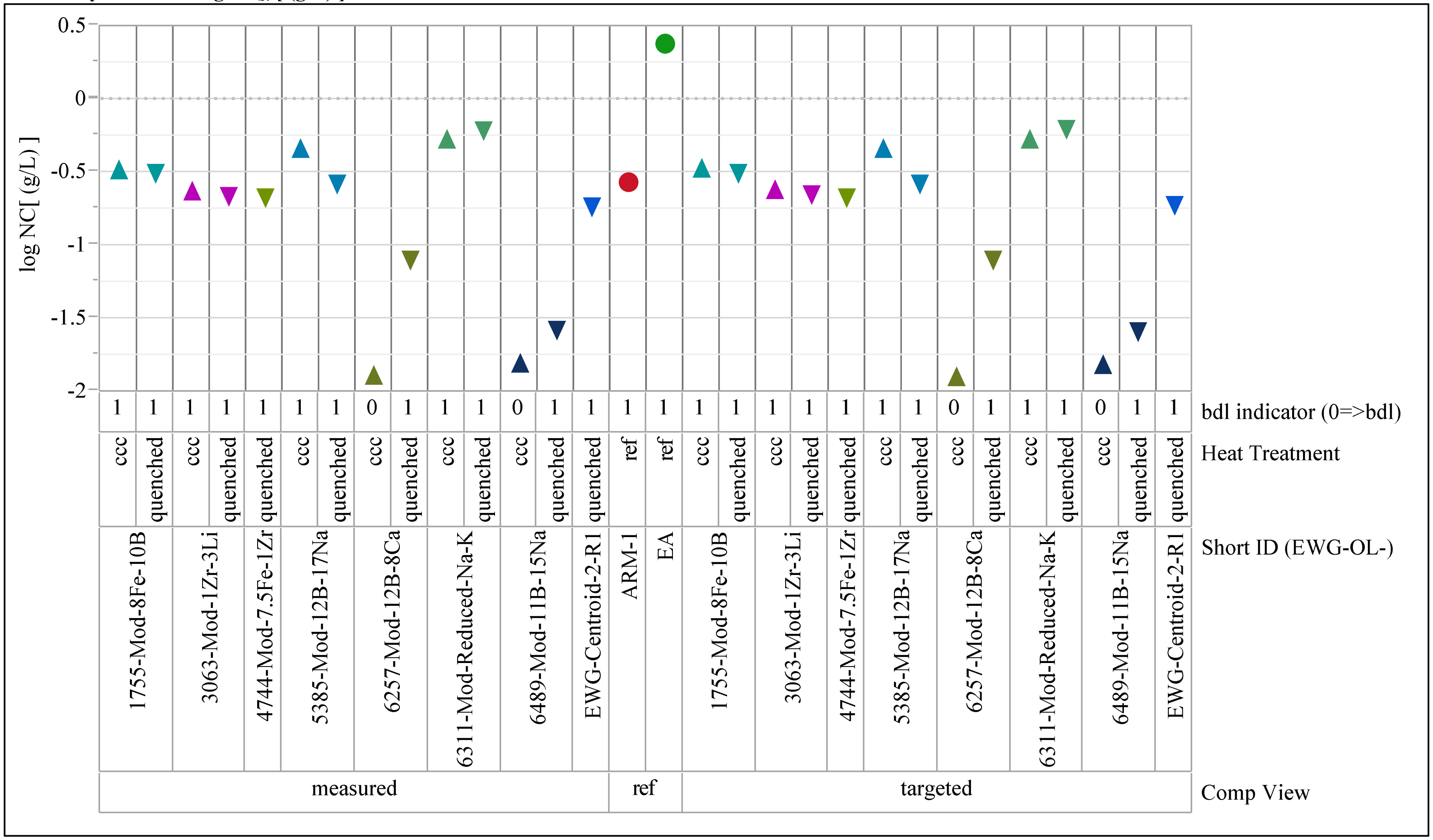


Exhibit B-3. Normalized PCT Results by Heat Treatment by Compositional View for Each Glass (continued)

Set=2, Analyte=B
Variability Chart for log NC_B [(g/L)]

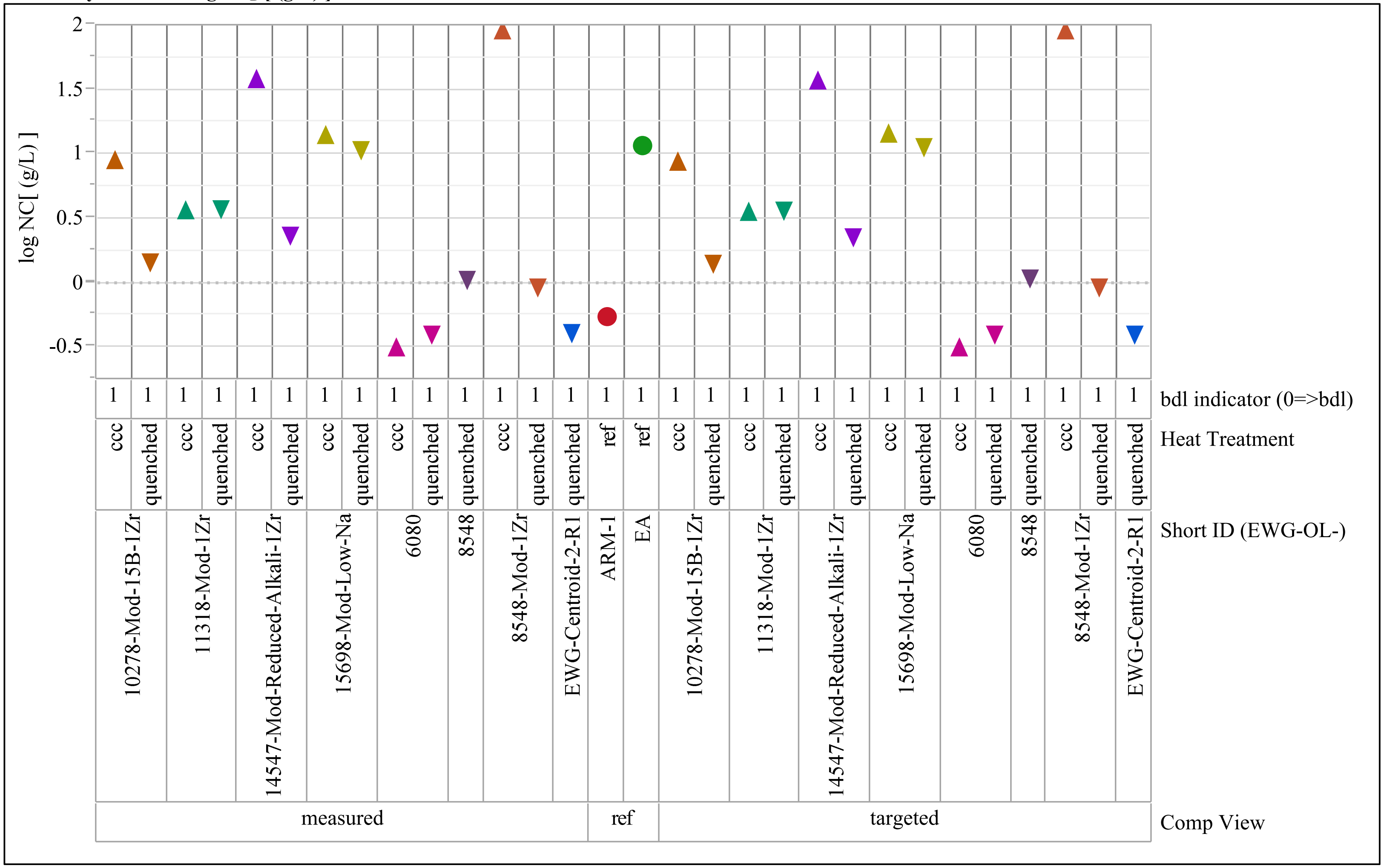


Exhibit B-3. Normalized PCT Results by Heat Treatment by Compositional View for Each Glass (continued)

Set=2, Analyte=Ca
Variability Chart for log NC_{Ca} [(g/L)]

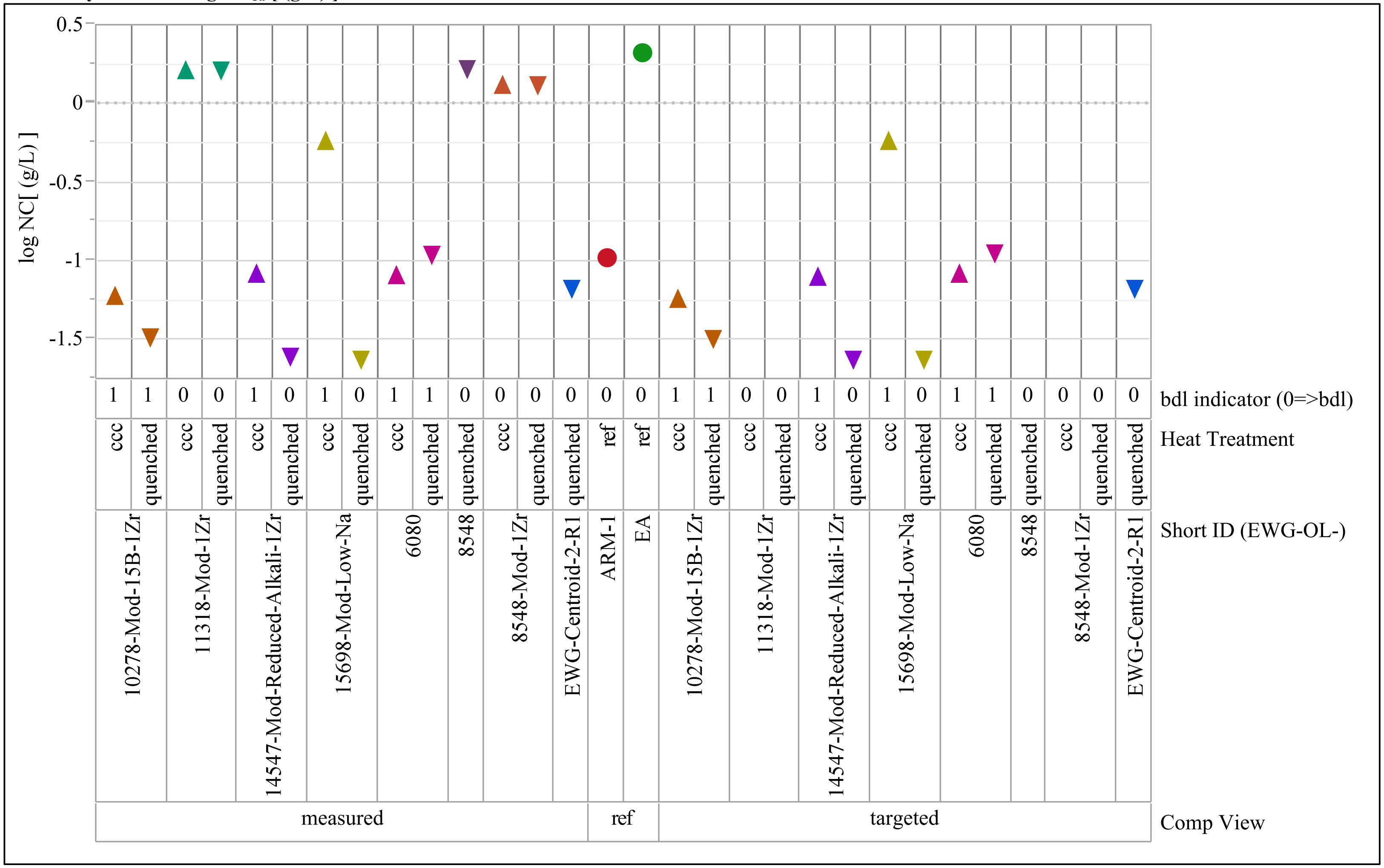


Exhibit B-3. Normalized PCT Results by Heat Treatment by Compositional View for Each Glass (continued)

Set=2, Analyte=K
Variability Chart for log NC_K [(g/L)]

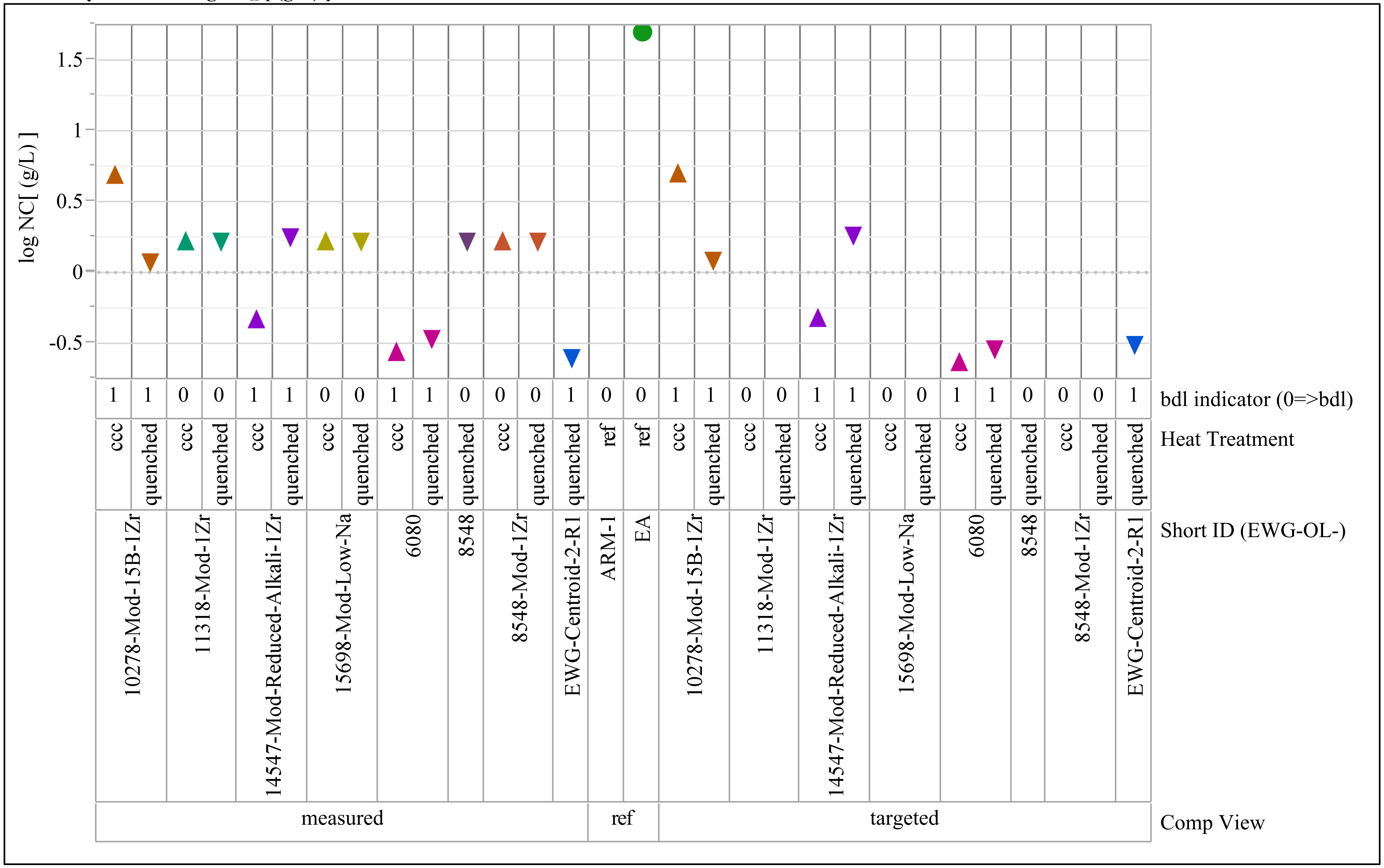


Exhibit B-3. Normalized PCT Results by Heat Treatment by Compositional View for Each Glass (continued)

Set=2, Analyte=Li
Variability Chart for log NC_{Li} [(g/L)]

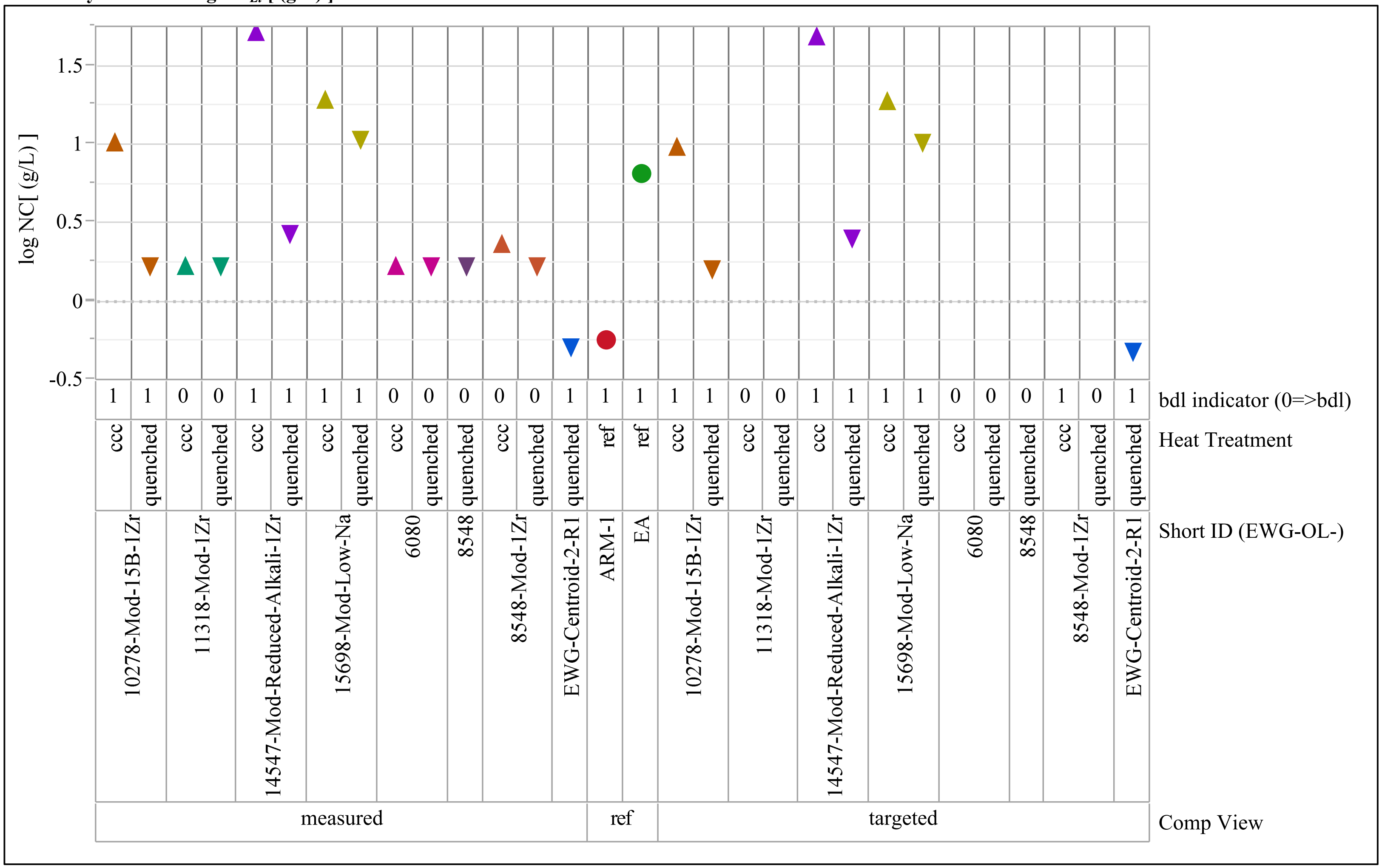


Exhibit B-3. Normalized PCT Results by Heat Treatment by Compositional View for Each Glass (continued)

Set=2, Analyte=Na
Variability Chart for log NC_{Na} [(g/L)]

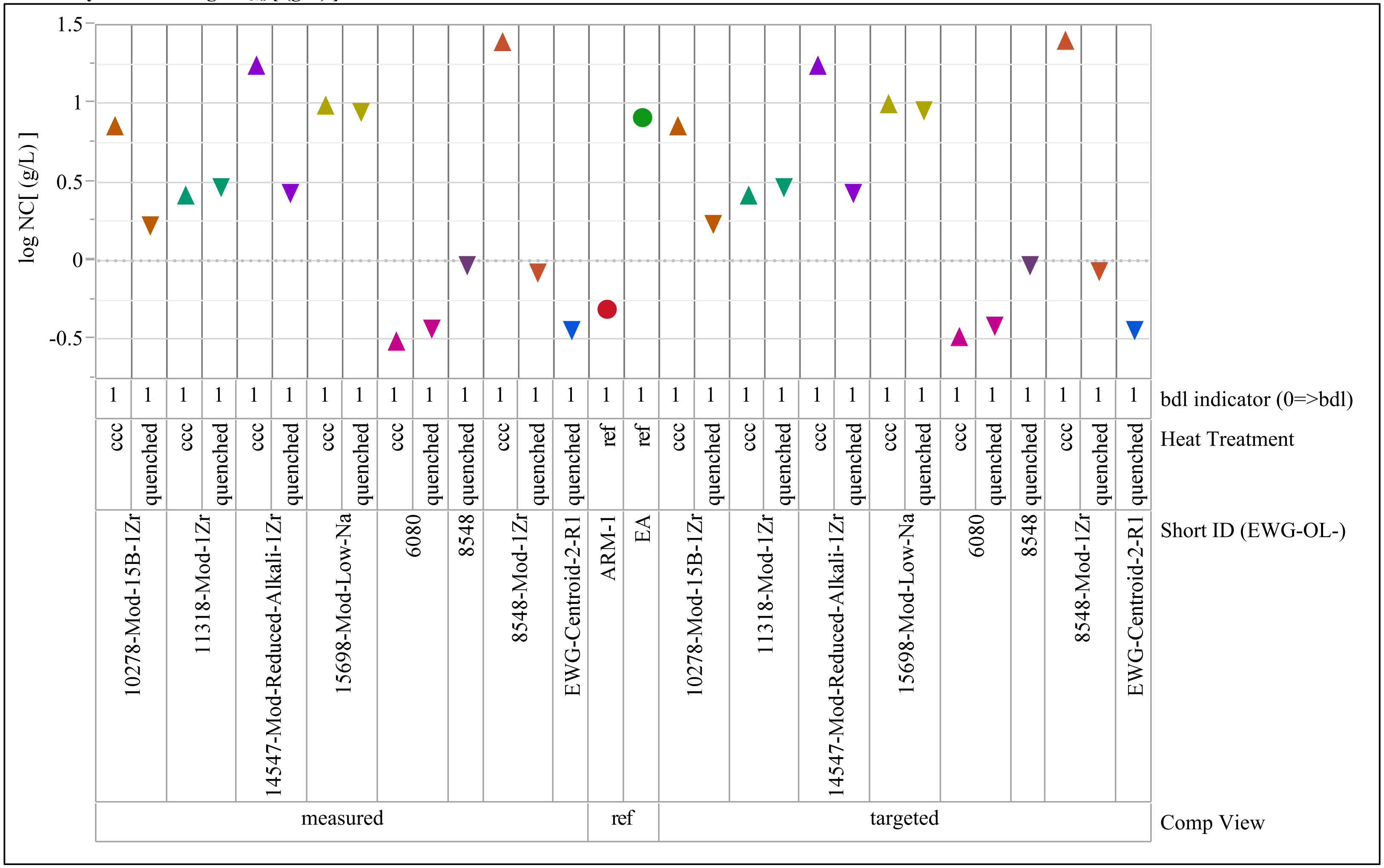


Exhibit B-3. Normalized PCT Results by Heat Treatment by Compositional View for Each Glass (continued)

Set=2, Analyte=P
Variability Chart for log NC_P [(g/L)]

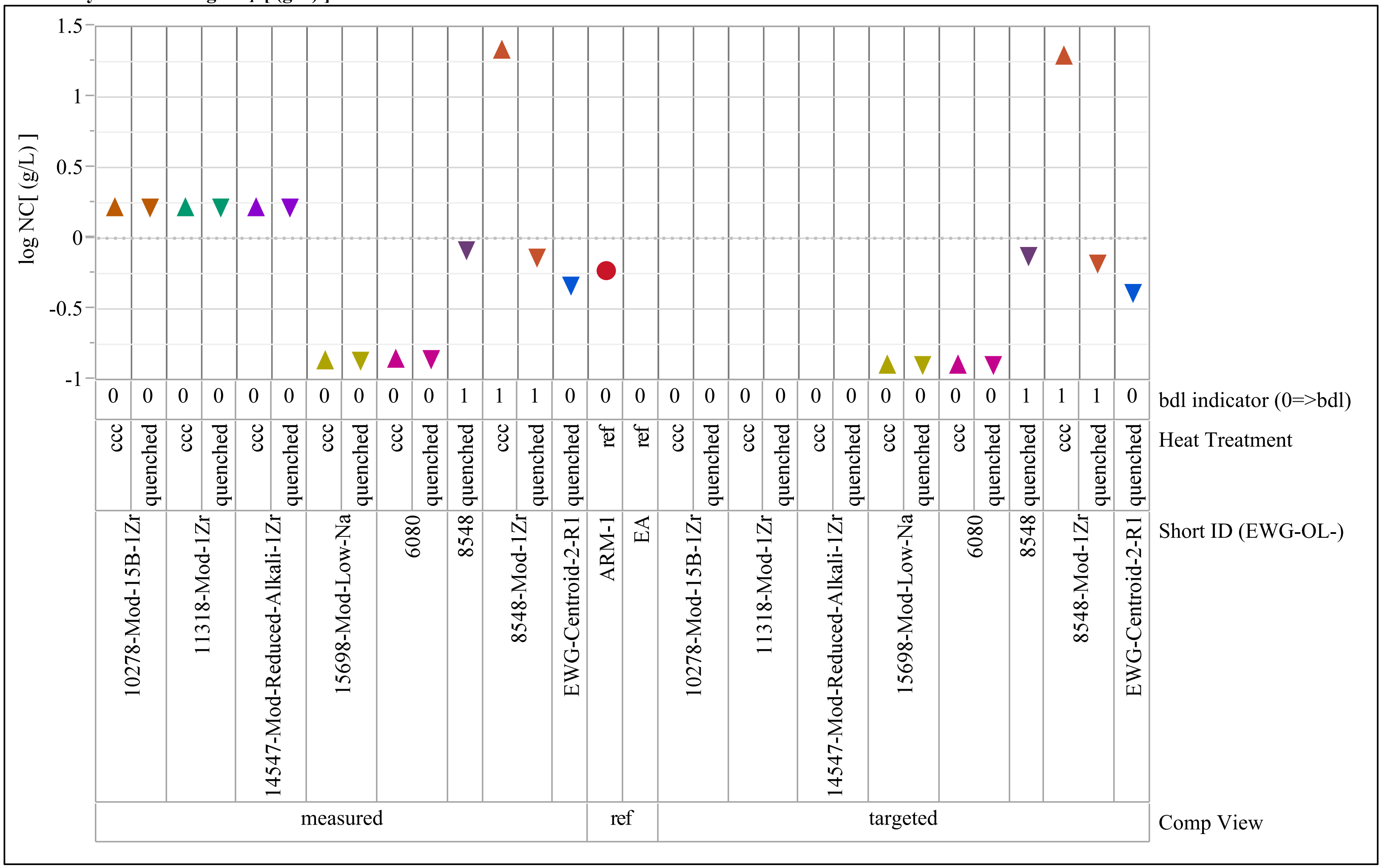
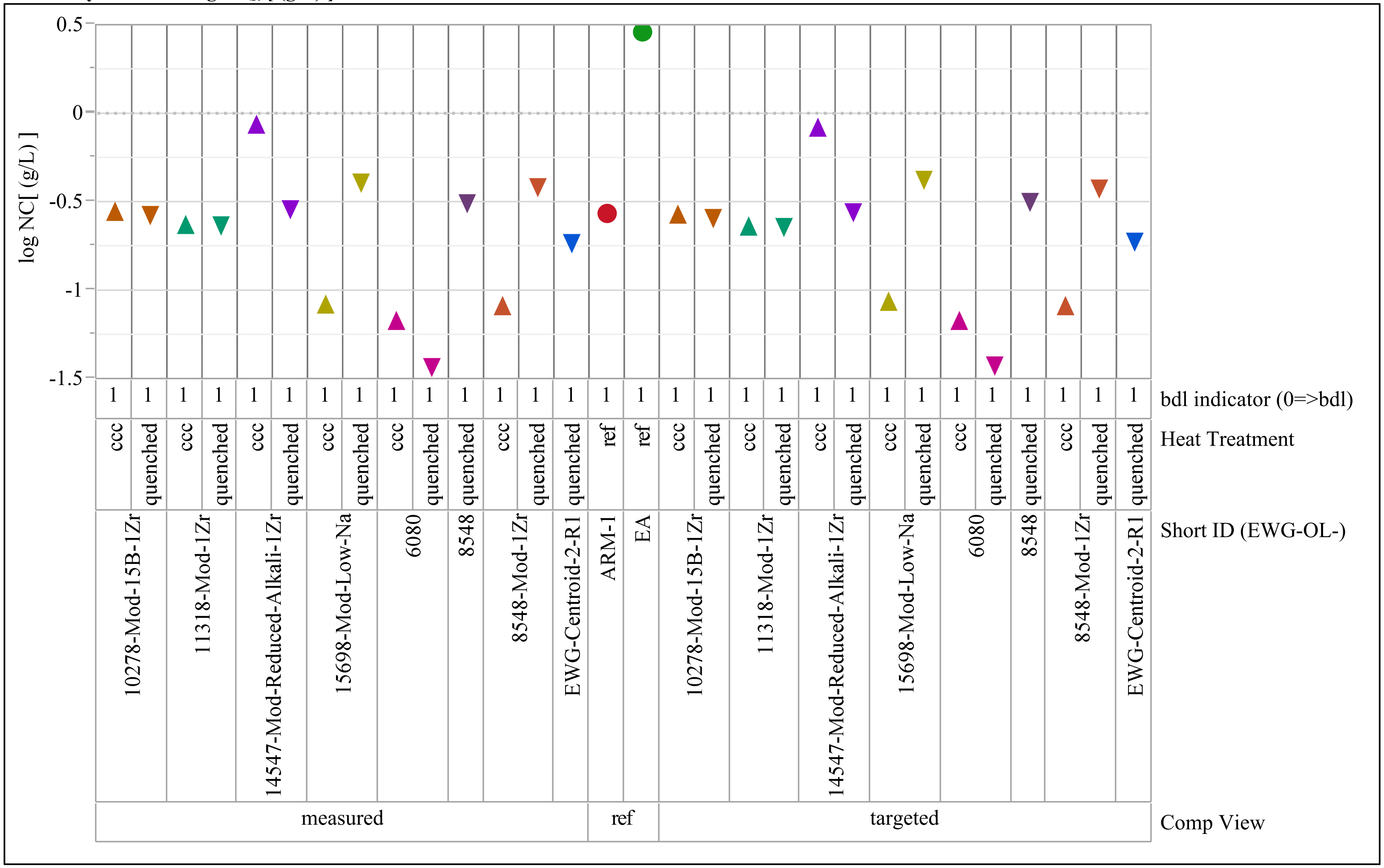


Exhibit B-3. Normalized PCT Results by Heat Treatment by Compositional View for Each Glass (continued)

Set=2, Analyte=Si
Variability Chart for log NC_{Si} [(g/L)]



Distribution:

J. W. Amoroso, 999-W
T. B. Brown, 773-A
H. H. Burns, 773-41A
A. S. Choi, 999-W
Y. S. Chou, PNNL
A. D. Cozzi, 999-W
C. L. Crawford, 773-42A
J. V. Crum, PNNL
D. E. Dooley, 999-W
A. P. Fellinger. 773-42A
S. D. Fink, 773-A
K. M. Fox, 999-W
J. C. Griffin, 773-A
E. K. Hansen, 999-W
C. C. Herman, 773-A
E. N. Hoffman, 999-W
J. E. Hyatt, 773-A
C. M. Jantzen, 773-A
F. C. Johnson, 999-W
D. S. Kim, PNNL
A. A. Kruger, DOE-ORP
D. J. McCabe, 773-42A
D. L. McClane, 999-W
D. H. McGuire, 999-W
D. H. Miller, 999-W
D. K. Peeler, PNNL
F. M. Pennebaker, 773-42A
M. R. Poirier, 773-42A
M. J. Schweiger, PNNL
M. E. Stone, 999-W
J. D. Vienna, PNNL
W. R. Wilmarth, 773-A
Records Administration (EDWS)