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Characterization of the Sulfur-Saturated Melt Versions of the HFG1 Study Glasses

M.C. Hsieh

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REVIEWS AND APPROVALS

AUTHORS:

_____
M.C. Hsieh, Applied Materials Research

TECHNICAL REVIEW:

_____
A. N. Stanfield, Applied Materials Research, Reviewed per E7 2.60

APPROVAL:

_____
J. Manna, Director, Material Science & Engineering

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EXECUTIVE SUMMARY

This report provides results from the chemical analyses of a series of sulfur-saturated melt (SSM) versions of the High Fluoride Glasses-1, a series of simulated nuclear waste glasses fabricated at PNNL. These data will be used to validate or identify areas of potential characterization improvements in the current glass property/composition models.

Chemical analyses were performed on a representative sample of each of the sulfur-saturated versions of the quenched glasses to allow for comparisons with the targeted compositions, as well as the measured compositions of the quenched glasses. The measured concentrations of fluoride were below the targeted values for all the study glasses. As expected, the measured concentrations of SO_3 in most of the glasses were higher than targeted due to the use of the sulfur saturation method in fabricating these glasses.

The wash solutions contained mainly sodium and sulfur, with moderate concentrations of fluoride.

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LIST OF ABBREVIATIONS

ARG-1	analytical reference glass-1
BDL	below detection limit
DOE	Department of Energy
EA	Environmental Assessment
HFG1	High Fluoride Glasses-1
HLW	high-level waste
IC	ion chromatography
ICP-OES	inductively coupled plasma – optical emission spectroscopy
ID	identifier
KH	potassium hydroxide fusion
LM	lithium metaborate fusion
LRM	low-activity test reference material
ORP	Office of River Protection
PF	sodium peroxide fusion
PNNL	Pacific Northwest National Laboratory
SRNL	Savannah River National Laboratory
SSM	sulfur-saturated melt
TTQAP	Task Technical and Quality Assurance Plan
wt.%	weight percent
WTP	Hanford Tank Waste Treatment and Immobilization Plant

1.0 Introduction

The U.S. Department of Energy (DOE) is responsible for building the Hanford Tank 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 Office of River Protection (ORP) has requested that the Savannah River National Laboratory (SRNL) contribute to current glass studies to support successful startup of the WTP, due to SRNL's recognized capabilities and expertise for glass waste form development.

As part of this effort, the Pacific Northwest National Laboratory (PNNL) is developing, batching, and fabricating simulated high-level waste (HLW) glasses to generate the associated property data needed to validate or identify areas of potential characterization improvements in the current glass property/composition models.[1] Currently, the models cover only a small fraction of the waste compositions projected in the Hanford tank farm; therefore, the models must be expanded to include high fluoride compositions to successfully complete the WTP mission. SRNL support of this work is defined in the Task Technical and Quality Assurance Plan (TTQAP).[2]

This report provides results from the chemical analyses of a series of sulfur-saturated melt (SSM) versions of simulated nuclear waste glasses fabricated at PNNL. The glasses were selected as part of a broader study of the influence of glass composition on chemical durability, sulfur retention, and other properties.[3,4] The glasses were designated the High Fluoride Glasses-1 (HFG1).

2.0 Experimental Procedure

2.1 Quality Assurance

Requirements for performing reviews of technical reports and the extent of review are established in Savannah River Site Manual E7, Procedure 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. Laboratory data for this study were recorded in the SRNL Electronic Laboratory Notebook system, experiment L6390-00441-01. The glasses provided by PNNL were fabricated following a Task Plan.[1]

JMP® Version 14.3.0 (SAS Institute, Inc.)[5] was used to support these analyses.

2.2 Glasses Selected for Study

The baseline (quenched) glass compositions in this study were selected and fabricated by PNNL. Characterization of the baseline glasses has been reported earlier.[6] Samples of each of the SSM versions of the study glasses, along with samples of the wash solutions resulting from the preparation of each of the SSM glasses, were received at SRNL for chemical composition analysis. PNNL identifiers (IDs) for the glass samples and the associated SRNL sample identifiers are listed in Table 2-1. The identifiers for the wash solutions are likewise listed in Table 2-2.

Table 2-1. Identifiers for the HFG1 SSM Study Glasses

PNNL Glass ID	SRNL Sample ID
HFG1-01-1-SSM-S	S-11764
HFG1-02-SSM-S	S-11765
HFG1-03-SSM-S	S-11766
HFG1-04-SSM-S	S-11767
HFG1-05-SSM-S	S-11768
HFG1-06-SSM-S	S-11769
HFG1-07-SSM-S	S-11770
HFG1-08-SSM-S	S-11771
HFG1-09-SSM-S	S-11772
HFG1-10-SSM-S	S-11773
HFG1-11-SSM-S	S-11774
HFG1-12-SSM-S	S-11775
HFG1-13-SSM-S	S-11776
HFG1-14-SSM-S	S-11777
HFG1-15-SSM-S	S-11778
HFG1-16-SSM-S	S-11779
HFG1-17-SSM-S	S-11780
HFG1-18-SSM-S	S-11781
HFG1-19-SSM-S	S-11782
HFG1-20-SSM-S	S-11783
EWG-HFG1-SSM-S	S-11784

Table 2-2. Identifiers for the HFG1 SSM Wash Solutions

PNNL Wash Solution ID	SRNL Sample ID
HFG1-01-1-SSM-W	S-11785
HFG1-02-SSM-W	S-11786
HFG1-03-SSM-W	S-11787
HFG1-04-SSM-W	S-11788
HFG1-05-SSM-W	S-11789
HFG1-06-SSM-W	S-11790
HFG1-07-SSM-W	S-11791
HFG1-08-SSM-W	S-11792
HFG1-09-SSM-W	S-11793
HFG1-10-SSM-W	S-11794
HFG1-11-SSM-W	S-11795
HFG1-12-SSM-W	S-11796
HFG1-13-SSM-W	S-11797
HFG1-14-SSM-W	S-11798
HFG1-15-SSM-W	S-11799
HFG1-16-SSM-W	S-11800
HFG1-17-SSM-W	S-11801
HFG1-18-SSM-W	S-11802
HFG1-19-SSM-W	S-11803
HFG1-20-SSM-W	S-11804
EWG-HFG1-SSM-W	S-11805

2.3 Glass Composition Analysis

Chemical analyses were performed under the auspices of an analytical plan[7] on a representative sample of each of the SSM glasses listed in Table 2-1 to allow for comparisons with the targeted and quenched compositions. Three dissolution techniques were used for preparing each of the glass samples, in duplicate, for analysis (lithium metaborate fusion (LM)[8], sodium peroxide fusion (PF),[9] and potassium hydroxide fusion (KH)[10]). Note that for some analytes, the analytical plan specified more than one preparation method for analysis. The results were reviewed and, in general, the method that provided better recovery of the analyte was selected for reporting.

Each of the duplicate samples was analyzed twice for each element of interest by inductively coupled plasma – optical emission spectroscopy (ICP-OES)[11] or ion chromatography (IC)[12], for a total of four measurements per element per glass. Glass standards were also intermittently measured to assess the performance of the ICP-OES and IC instruments over the course of these analyses. Specifically, several samples of the Analytical Reference Glass-1 (ARG-1)[13] and several samples of the low-activity test reference material (LRM)[14] were included as part of the analytical plan. The ARG-1 composition reported as the "Corning, Inc., Glass Composition"[13] and the LRM composition reported as the "Consensus Average"[14] are used as the reference compositions for these glasses. The preparation and measurement methods used for each of the reported glass components are listed in Table 2-3.

Table 2-3. Preparation and Measurement Methods Used in Reporting the Analyte Concentrations of the HFG1 SSM Study Glasses

Analyte	Preparation Method	Measurement Method
Al	LM	ICP-OES
B	PF	ICP-OES
Ca	LM	ICP-OES
Cr	LM	ICP-OES
F	KH	IC
Fe	LM	ICP-OES
K	LM	ICP-OES
Li	PF	ICP-OES
Mn	LM	ICP-OES
Na	LM	ICP-OES
P	LM	ICP-OES
S	LM	ICP-OES
Si	PF	ICP-OES
Zn	PF	ICP-OES
Zr	PF	ICP-OES

2.4 Wash Solution Analysis

Chemical analyses were performed under the auspices of an analytical plan[7] on a representative sample of each of the wash solutions resulting from the preparation of the SSM versions of the glasses, as listed in Table 2-2. The samples were diluted at SRNL based on the expected concentrations of the species in solution in preparation for the analysis.

Each of the samples was analyzed in triplicate for each element of interest by ICP-OES[11] and IC[12]. Solution standards[a] and blanks were also intermittently measured to assess the performance of the ICP-OES and IC instruments over the course of these analyses. The measurement methods used for each of the reported wash solution components are listed in Table 2-4.

Table 2-4. Measurement Methods Used in Reporting the Analyte Concentrations of the HFG1 SSM Wash Solutions

Analyte	Measurement Method
Al	ICP-OES
B	ICP-OES
Ca	ICP-OES
Cr	ICP-OES
F^-	IC
Fe	ICP-OES
K	ICP-OES
Li	ICP-OES
Mn	ICP-OES
Na	ICP-OES
P	ICP-OES
PO_4^{3-}	IC
S	ICP-OES
SO_4^{2-}	IC
Si	ICP-OES
Zn	ICP-OES
Zr	ICP-OES

3.0 Results and Discussion

3.1 Review and Evaluation of the SSM Glass Composition Measurements

Table A-1 in Appendix A provides the elemental concentration measurements in wt.% for the study glasses as prepared by the LM method. Table A-2 in Appendix A provides the elemental concentration measurements in wt.% for the study glasses as prepared by the PF method. Table A-3 in Appendix A provides the elemental concentration measurements in wt.% for the study glasses as prepared by the KH method. Elemental measurements for samples of the ARG-1 and LRM standard glasses are also included in the tables of Appendix A. These unprocessed data are provided so that the values are readily available should they be of interest for future reviews.

3.1.1 Treatment of Detection Limits

The elemental concentrations in Table A-1, Table A-2, and Table A-3 of Appendix A were converted to oxide concentrations by multiplying the values of each element by the gravimetric factor for the corresponding oxide. A concentration measurement that was reported to be below the detection limit was set to the detection limit for the purposes of data review and calculating a sum of oxides for each glass. Concentration measurements that were below the detection limit (BDL) are denoted with a less than symbol (<).

3.1.2 Measurements in Analytical Sequence

Exhibit A-1 in Appendix A provides plots of the wt.% oxide measurements calculated for each sample by oxide and analytical block. The plots are in analytical sequence within each calibration block. Different

[a] ICP multi-element custom solutions, product numbers SM-744-013 and SM-744-014, High Purity Standards, Charleston, SC.

symbols and colors are used to represent each of the study and standard glasses. These plots include the wt.% oxide measurements calculated from all of the measurement data from Table A-1, Table A-2, and Table A-3 in Appendix A, with each plotted point identified by its Lab ID (from the analytical study plan)[7]. Plotting the data in this format provides an opportunity to identify gross trends in performance of the analytical instruments within and among calibration blocks. A review of these plots did not identify any gross patterns or trends in the analytical process over the course of these measurements. In all cases, the LRM standard glass measurements were within specification.[11] Any minor calibration effects typical of ICP-OES analyses are mitigated by taking the average of the measurements for each analyte.

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 ARG-1 and LRM reference glasses) 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. There were no indications of errors in preparation or measurement that had to be addressed in treatment of the data.

3.1.4 Results for the LRM Standard

Exhibit A-3 in Appendix A provides a comparison of the LRM results to their acceptability limits utilized by SRNL.[11] 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 each element of interest. The results show that all measurements of the LRM elements of interest were within the acceptability limits during the execution of these analyses.

3.1.5 Measured versus Targeted Compositions

All the measurements for each oxide for each glass (Table A-1, Table A-2, and Table A-3 in Appendix A) were averaged to determine a representative chemical composition for each glass. A sum of oxides was also computed for each glass based upon the averaged 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-4 in Appendix A provides a comparison of the average measured compositions and targeted compositions. The measured sums of oxides for all glasses fall within the interval of 96.5 to 103 wt.%, indicating acceptable recovery of the glass components.[15] Entries in Table A-4 show the relative differences between the measured values and the targeted values for the oxides with measured and targeted values above 1 wt.%. The relative differences are shaded if they are 10% or more and are summarized below.

- F^- relative differences were -10% or more for all study glasses.
- K_2O relative differences were -10% or more for four of the study glasses:
  - HFG1-01-1-SSM-S, HFG1-04-SSM-S, HFG1-15-SSM-S, and HFG1-16-SSM-S.
- The Li_2O relative difference was more than -10% for HFG1-02-SSM-S.
- The ZrO_2 relative difference was more than -10% for HFG1-16-SSM-S.
- As expected, the measured concentrations of SO_3 in all study glasses were higher than targeted due to the use of the sulfur saturation method in fabricating these glasses.

Measured compositions of the ARG-1 standard glass are within 10% of the reference values.[13]

3.2 Comparison of Measured Compositions of Baseline and SSM Glasses

Exhibit A-5 in Appendix A provides a comparison of the measured oxide concentrations among the baseline (quenched) and SSM versions of the study glasses. A review of Exhibit A-5 led to the following observations:

- The measured concentrations of F^- was lower in the SSM versions of the study glasses.
- The measured SO_3 concentrations were higher for SSM versions of the study glasses, as expected, due to the use of the sulfur saturation method in fabricating these glasses.

The discussion of the analyses of the wash solutions, provided in Section 3.3, may provide further insight into the measured compositions of the SSM glasses.

3.3 Review and Evaluation of Wash Solution Measurements

Table B-1 in Appendix B provides the elemental concentration measurements in mg/L for the wash solutions as measured by ICP-OES. Table B-2 in Appendix B provides the anion concentration measurements in mg/L for the wash solutions as measured by IC. Elemental measurements of the blanks and standard solutions are included in the tables of Appendix B. These unprocessed data are provided so that the values are readily available should they be of interest for future reviews.

3.3.1 Treatment of Detection Limits

The elemental and anion concentrations in Table B-1 and Table B-2 of Appendix B include measurements that were reported to be below the detection limit. These values were set to the detection limit for the purposes of data review and of calculating an average composition for each wash solution.

3.3.2 Measurements in Analytical Sequence

Exhibit B-1 in Appendix B provides plots of the mg/L measurements generated for each wash solution sample by element or anion and analytical block. The plots are in analytical sequence within each calibration block. Different symbols and colors are used to represent each of the wash solutions and standard solutions. These plots include all of the measurement data from Table B-1 and Table B-2 in Appendix B, with each plotted point identified by its Lab ID and Solution ID. Plotting the data in this format provides an opportunity to identify gross trends in performance of the analytical instruments within and among calibration blocks. A review of these plots did not identify any gross patterns or trends in the analytical process over the course of these measurements. In all cases, the instrument check standards were within specification. Any minor calibration effects typical of ICP-OES analyses are mitigated by taking the average of the measurements for each analyte.

3.3.3 Composition Measurements by Wash Solution Identifier

Exhibit B-2 in Appendix B provides plots of the elemental and anion concentration measurements grouped by the wash solution identifier (including the blanks and standard solutions). Different symbols and colors are used to represent the different solutions. Plotting the data in this format provides an opportunity to review the values for each individual solution as a function of the triplicate measurements. A review of the plots presented in these exhibits reveals the repeatability of the three individual values for each analyte for each solution. These observations were not considered to indicate 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 the wash solutions.

3.3.4 Results for the Standard Solutions

Table B-3 in Appendix B provides comparisons of the standard solution results to their reference values. Although not a statistical comparison, the results in this table indicate no issues with the performance of the analyses.

3.3.5 Measured Compositions of the Wash Solutions

From the discussion of Section 3.3.3, all the measurements for each analyte for each wash solution (Table B-1 and Table B-2 of Appendix B) were averaged to determine a representative chemical composition for each solution. Table B-4 in Appendix B provides a summary of the average measured compositions of the wash solutions. The concentrations of PO_4^{3-} and SO_4^{2-} reported in these tables include the measured values from both ICP-OES and IC for comparison. The measured S and P concentrations from the ICP-OES analyses were converted to PO_4^{3-} and SO_4^{2-} concentrations by multiplying by the appropriate gravimetric factors to support these comparisons. A graphical representation of the average chemical composition data for each wash solution is provided in Exhibit B-3. The following observations are offered from the review of Table B-4 and Exhibit B-3:

- The wash solutions contained mainly Na (about 620-1410 mg/L) and S (about 410-630 mg/L), which could be attributed to the excess sodium sulfate added as part of the SSM preparation process.
- The wash solutions contained a moderate amount of F^- (60-450 mg/L).
- The measured concentrations of B, Ca, Cr, K, Li, P, and Si in the wash solutions were generally below 100 mg/L.
- The measured concentrations of Al, Fe, Mn, Zn, and Zr in the wash solutions were near or below the detection limits.
- The measured concentrations of P were similar by both the ICP-OES and IC methods (ICP-OES data converted to PO_4^{3-} basis for comparison) and were in the range of <10 to 26 mg/L PO_4^{3-}.
- The measured concentrations of S were similar by both the ICP-OES and IC methods (ICP-OES data converted to SO_4^{2-} basis for comparison) and were in the range of about 1230-1920 mg/L SO_4^{2-}.

4.0 Summary

Chemical analyses were performed on a series of SSM versions of simulated nuclear waste glasses and resulting wash solutions with ICP-OES and IC. The glasses were selected and fabricated by PNNL as part of a broader study of the influence of glass composition on chemical durability, sulfur retention, and other properties.

The measured concentrations of fluoride were below the targeted values for all the SSM glasses. As expected, the measured concentrations of SO_3 in most of the glasses were higher than targeted due to the use of the sulfur saturation method in fabricating these glasses.

The wash solutions contained mainly sodium and sulfur, with moderate concentrations of fluoride. As expected, the measured concentrations of SO_3 in the SSM glasses were higher than targeted due to the use of the sulfur saturation method in fabricating these glasses. No issues with the analytical process were found for the wash solution measurements.

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Appendix A. Tables and Exhibits Supporting the HFG1 SSM Glass Composition Measurements

Table A-1. Measurements of the Samples Prepared by LM in Analytical Sequence

Glass ID	Block	Sub - Block	Seq	Lab ID	Al (wt.%)	Ca (wt.%)	Cr (wt.%)	Fe (wt.%)	K (wt.%)	Mn (wt.%)	Na (wt.%)	P (wt.%)	S (wt.%)
LRM	1	1	1	LRMLM111	5.14	0.324	0.139	0.974	1.23	<0.100	14.9	0.191	0.0969
ARG-1	1	1	2	ARG1LM111	2.45	1.04	<0.100	9.11	2.14	1.39	8.24	0.101	<0.0500
HFG1-15-SSM-S	1	1	3	S-11778LM21	2.59	3.16	0.100	0.257	1.02	0.135	11.6	<0.100	0.736
HFG1-09-SSM-S	1	1	4	S-11772LM11	3.09	3.68	<0.100	0.282	0.295	0.147	13.0	0.100	0.596
HFG1-05-SSM-S	1	1	5	S-11768LM21	2.10	0.240	0.101	0.285	0.204	0.154	15.7	0.101	0.581
HFG1-20-SSM-S	1	1	6	S-11783LM11	5.18	1.49	<0.100	0.179	<0.100	<0.100	16.9	<0.100	0.644
EWG-HFG1-SSM-S	1	1	7	S-11784LM21	3.64	1.68	<0.100	<0.100	<0.100	<0.100	6.88	0.234	<0.0500
HFG1-19-SSM-S	1	1	8	S-11782LM21	4.79	3.27	<0.100	<0.100	0.885	<0.100	16.1	<0.100	0.601
EWG-HFG1-SSM-S	1	1	9	S-11784LM11	3.55	1.67	<0.100	<0.100	<0.100	<0.100	6.99	0.230	<0.0500
LRM	1	1	10	LRMLM112	5.26	0.324	0.137	1.07	1.23	<0.100	15.0	0.188	0.0959
ARG-1	1	1	11	ARGLM112	2.57	1.08	<0.100	10.1	2.20	1.54	8.24	0.101	0.0525
HFG1-09-SSM-S	1	1	12	S-11772LM21	3.35	3.90	<0.100	0.290	0.291	0.154	12.5	0.101	0.613
HFG1-15-SSM-S	1	1	13	S-11778LM11	2.83	3.44	0.102	0.264	1.09	0.138	12.1	<0.100	0.748
HFG1-02-SSM-S	1	1	14	S-11765LM21	4.52	1.97	<0.100	0.137	0.804	<0.100	11.3	<0.100	0.326
HFG1-02-SSM-S	1	1	15	S-11765LM11	4.41	1.96	<0.100	0.139	0.850	<0.100	11.6	<0.100	0.327
HFG1-05-SSM-S	1	1	16	S-11768LM11	2.13	0.244	<0.100	0.283	0.207	0.156	15.8	0.101	0.583
HFG1-20-SSM-S	1	1	17	S-11783LM21	5.39	1.54	<0.100	0.181	<0.100	0.103	17.0	<0.100	0.653
HFG1-19-SSM-S	1	1	18	S-11782LM11	4.84	3.36	<0.100	<0.100	0.874	<0.100	16.2	<0.100	0.636
LRM	1	1	19	LRMLM113	5.48	0.325	0.135	1.09	1.28	<0.100	14.7	0.188	0.103
ARG-1	1	1	20	ARGLM113	2.64	1.12	<0.100	10.3	2.28	1.56	8.08	0.102	<0.0500
LRM	1	2	1	LRMLM121	4.98	0.323	0.133	0.957	1.17	<0.100	14.7	0.177	0.0911
ARG-1	1	2	2	ARG1LM121	2.52	1.07	<0.100	9.51	2.31	1.44	8.37	<0.100	<0.0500
HFG1-19-SSM-S	1	2	3	S-11782LM22	4.59	3.22	<0.100	<0.100	0.851	<0.100	16.0	<0.100	0.600
HFG1-15-SSM-S	1	2	4	S-11778LM22	2.61	3.28	0.100	0.256	1.05	0.134	11.6	<0.100	0.733
EWG-HFG1-SSM-S	1	2	5	S-11784LM22	3.41	1.63	<0.100	<0.100	<0.100	<0.100	6.83	0.223	<0.0500
HFG1-20-SSM-S	1	2	6	S-11783LM12	5.04	1.48	<0.100	0.176	<0.100	<0.100	16.5	<0.100	0.631
HFG1-05-SSM-S	1	2	7	S-11768LM12	2.03	0.241	<0.100	0.281	0.198	0.155	15.2	<0.100	0.569
HFG1-02-SSM-S	1	2	8	S-11765LM22	4.21	1.88	<0.100	0.137	0.806	<0.100	11.4	<0.100	0.315
HFG1-20-SSM-S	1	2	9	S-11783LM22	5.09	1.47	<0.100	0.181	<0.100	0.102	16.7	<0.100	0.656
LRM	1	2	10	LRMLM122	5.07	0.329	0.131	0.967	1.22	<0.100	15.1	0.177	0.0902
ARG-1	1	2	11	ARGLM122	2.45	1.05	<0.100	9.39	2.21	1.42	8.27	<0.100	<0.0500
HFG1-19-SSM-S	1	2	12	S-11782LM12	4.63	3.25	<0.100	<0.100	0.862	<0.100	15.9	<0.100	0.602
HFG1-02-SSM-S	1	2	13	S-11765LM12	4.23	1.91	<0.100	0.137	0.793	<0.100	11.0	<0.100	0.305
HFG1-09-SSM-S	1	2	14	S-11772LM12	3.08	3.79	<0.100	0.282	0.294	0.148	12.8	<0.100	0.613

Table A-1. Measurements of the Samples Prepared by LM in Analytical Sequence (continued)

Glass ID	Block	Sub - Block	Seq	Lab ID	Al (wt.%)	Ca (wt.%)	Cr (wt.%)	Fe (wt.%)	K (wt.%)	Mn (wt.%)	Na (wt.%)	P (wt.%)	S (wt.%)
HFG1-15-SSM-S	1	2	15	S-11778LM12	2.64	3.31	0.101	0.262	1.06	0.137	11.3	<0.100	0.741
HFG1-05-SSM-S	1	2	16	S-11768LM22	2.07	0.241	<0.100	0.280	0.196	0.154	15.7	<0.100	0.579
HFG1-09-SSM-S	1	2	17	S-11772LM22	3.12	3.73	<0.100	0.288	0.288	0.153	12.7	<0.100	0.620
EWG-HFG1-SSM-S	1	2	18	S-11784LM12	3.48	1.67	<0.100	<0.100	<0.100	<0.100	6.96	0.223	<0.0500
LRM	1	2	19	LRMLM123	4.99	0.328	0.132	0.958	1.19	<0.100	14.8	0.180	0.0941
ARG-1	1	2	20	ARGLM123	2.48	1.06	<0.100	9.47	2.23	1.44	8.01	<0.100	<0.0500
LRM	2	1	1	LRMLM211	5.05	0.354	0.143	0.973	1.18	<0.100	14.9	0.200	0.0966
ARG-1	2	1	2	ARG1LM211	2.43	1.10	<0.100	9.36	2.10	1.41	8.12	0.109	<0.0500
HFG1-03-SSM-S	2	1	3	S-11766LM11	2.06	1.56	<0.100	0.126	0.628	<0.100	11.9	<0.100	0.279
HFG1-13-SSM-S	2	1	4	S-11776LM11	4.34	2.59	<0.100	0.261	0.435	0.127	9.68	<0.100	0.537
HFG1-03-SSM-S	2	1	5	S-11766LM21	2.08	1.56	<0.100	0.129	0.615	<0.100	12.0	<0.100	0.289
HFG1-04-SSM-S	2	1	6	S-11767LM11	1.00	4.03	<0.100	0.194	1.04	<0.100	16.9	<0.100	0.857
HFG1-18-SSM-S	2	1	7	S-11781LM21	2.71	0.355	<0.100	0.111	0.327	<0.100	10.0	<0.100	0.408
HFG1-13-SSM-S	2	1	8	S-11776LM21	4.30	2.57	<0.100	0.265	0.440	0.129	9.51	<0.100	0.547
HFG1-12-SSM-S	2	1	9	S-11775LM21	1.50	4.32	<0.100	<0.100	0.526	<0.100	9.88	<0.100	0.529
LRM	2	1	10	LRMLM212	4.96	0.358	0.144	0.962	1.15	<0.100	14.8	0.201	0.0996
ARG-1	2	1	11	ARGLM212	2.45	1.11	<0.100	9.39	2.14	1.42	8.26	0.110	<0.0500
HFG1-11-SSM-S	2	1	12	S-11774LM11	4.08	<0.100	<0.100	0.256	0.723	0.137	12.8	<0.100	0.293
HFG1-12-SSM-S	2	1	13	S-11775LM11	1.51	4.36	<0.100	<0.100	0.516	<0.100	9.98	<0.100	0.540
HFG1-04-SSM-S	2	1	14	S-11767LM21	0.989	3.99	<0.100	0.195	1.01	<0.100	16.7	<0.100	0.868
HFG1-16-SSM-S	2	1	15	S-11779LM11	4.36	4.20	<0.100	0.205	0.936	0.108	15.5	<0.100	0.767
HFG1-11-SSM-S	2	1	16	S-11774LM21	4.16	<0.100	<0.100	0.241	0.756	0.131	13.1	<0.100	0.289
HFG1-16-SSM-S	2	1	17	S-11779LM21	4.47	4.28	<0.100	0.203	0.959	0.107	15.1	<0.100	0.766
HFG1-18-SSM-S	2	1	18	S-11781LM11	2.76	0.360	<0.100	0.116	0.340	<0.100	10.3	<0.100	0.420
LRM	2	1	19	LRMLM213	4.98	0.360	0.144	0.977	1.16	<0.100	14.9	0.202	0.0872
ARG-1	2	1	20	ARGLM213	2.54	1.13	<0.100	9.73	2.40	1.47	8.31	0.109	0.0500
LRM	2	2	1	LRMLM221	5.00	0.333	0.141	0.965	1.19	<0.100	14.9	0.198	0.0899
ARG-1	2	2	2	ARG1LM221	2.48	1.06	<0.100	9.44	2.19	1.43	8.23	0.107	<0.0500
HFG1-11-SSM-S	2	2	3	S-11774LM22	4.13	<0.100	<0.100	0.238	0.709	0.128	12.7	<0.100	0.285
HFG1-18-SSM-S	2	2	4	S-11781LM12	2.73	0.328	<0.100	0.114	0.314	<0.100	10.1	<0.100	0.407
HFG1-13-SSM-S	2	2	5	S-11776LM22	4.40	2.47	<0.100	0.127	0.594	<0.100	9.93	<0.100	0.288
HFG1-04-SSM-S	2	2	6	S-11767LM12	0.976	3.71	<0.100	0.191	1.01	<0.100	17.0	<0.100	0.846
HFG1-18-SSM-S	2	2	7	S-11781LM22	2.70	0.322	<0.100	0.109	0.311	<0.100	10.0	<0.100	0.397
HFG1-12-SSM-S	2	2	8	S-11775LM22	1.50	4.08	<0.100	<0.100	0.497	<0.100	9.92	<0.100	0.520

Table A-1. Measurements of the Samples Prepared by LM in Analytical Sequence (continued)

Glass ID	Block	Sub - Block	Seq	Lab ID	Al (wt.%)	Ca (wt.%)	Cr (wt.%)	Fe (wt.%)	K (wt.%)	Mn (wt.%)	Na (wt.%)	P (wt.%)	S (wt.%)
HFG1-16-SSM-S	2	2	9	S-11779LM22	4.50	4.07	<0.100	0.202	0.970	0.107	15.0	<0.100	0.757
LRM	2	2	10	LRMLM222	5.04	0.297	0.134	0.971	1.19	<0.100	14.4	0.180	0.0937
ARG-1	2	2	11	ARGLM222	2.47	1.05	<0.100	9.42	2.17	1.43	8.24	0.106	<0.0500
HFG1-11-SSM-S	2	2	12	S-11774LM12	4.13	<0.100	<0.100	0.250	0.687	0.133	12.7	<0.100	0.281
HFG1-13-SSM-S	2	2	13	S-11776LM12	4.41	2.47	<0.100	0.259	0.408	0.126	9.67	<0.100	0.530
HFG1-12-SSM-S	2	2	14	S-11775LM12	1.50	4.09	<0.100	<0.100	0.493	<0.100	9.75	<0.100	0.515
HFG1-04-SSM-S	2	2	15	S-11767LM22	0.987	3.75	<0.100	0.187	1.02	<0.100	16.4	<0.100	0.830
HFG1-03-SSM-S	2	2	16	S-11766LM12	2.13	1.51	<0.100	0.123	0.591	<0.100	12.1	<0.100	0.272
HFG1-16-SSM-S	2	2	17	S-11779LM12	4.32	3.92	<0.100	0.202	0.916	0.106	12.8	<0.100	0.736
HFG1-03-SSM-S	2	2	18	S-11766LM22	2.09	1.48	<0.100	0.125	0.579	<0.100	9.89	<0.100	0.274
LRM	2	2	19	LRMLM223	5.05	0.292	0.132	0.973	1.20	<0.100	14.7	0.178	0.0956
ARG-1	2	2	20	ARGLM223	2.52	1.07	<0.100	9.51	2.25	1.45	8.24	<0.100	<0.0500
LRM	3	1	1	LRMLM311	4.81	0.342	0.142	0.938	1.14	<0.100	15.4	0.194	0.0945
ARG-1	3	1	2	ARG1LM311	2.36	1.06	<0.100	9.13	2.07	1.39	8.64	0.107	<0.0500
HFG1-08-SSM-S	3	1	3	S-11771LM11	1.69	3.12	<0.100	0.275	0.997	0.142	17.1	<0.100	0.482
HFG1-14-SSM-S	3	1	4	S-11777LM11	1.32	4.15	<0.100	<0.100	0.106	<0.100	16.2	<0.100	0.661
HFG1-08-SSM-S	3	1	5	S-11771LM21	1.70	3.11	<0.100	0.276	1.02	0.144	16.8	<0.100	0.484
HFG1-07-SSM-S	3	1	6	S-11770LM11	4.91	<0.100	<0.100	<0.100	1.01	<0.100	13.5	<0.100	0.304
HFG1-14-SSM-S	3	1	7	S-11777LM21	1.32	4.12	<0.100	<0.100	0.105	<0.100	16.1	<0.100	0.685
HFG1-17-SSM-S	3	1	8	S-11780LM21	2.52	2.71	<0.100	0.125	0.163	<0.100	13.3	<0.100	0.592
HFG1-07-SSM-S	3	1	9	S-11770LM21	4.97	<0.100	<0.100	<0.100	0.957	<0.100	13.6	<0.100	0.288
LRM	3	1	10	LRMLM312	4.84	0.342	0.142	0.940	1.15	<0.100	15.4	0.194	0.0864
ARG-1	3	1	11	ARGLM312	2.42	1.09	<0.100	9.30	2.17	1.40	8.47	0.106	<0.0500
HFG1-10-SSM-S	3	1	12	S-11773LM11	3.21	2.49	<0.100	<0.100	0.594	<0.100	14.6	<0.100	0.485
HFG1-06-SSM-S	3	1	13	S-11769LM11	2.89	1.05	<0.100	0.146	0.916	<0.100	17.0	<0.100	0.643
HFG1-17-SSM-S	3	1	14	S-11780LM11	2.54	2.74	<0.100	0.121	0.153	<0.100	13.3	<0.100	0.572
HFG1-01-1-SSM-S	3	1	15	S-11764LM11	5.00	0.513	<0.100	0.137	1.11	<0.100	10.7	<0.100	0.348
HFG1-01-1-SSM-S	3	1	16	S-11764LM21	5.02	0.519	<0.100	0.137	1.12	<0.100	10.8	<0.100	0.353
HFG1-06-SSM-S	3	1	17	S-11769LM21	2.86	1.03	<0.100	0.144	0.879	<0.100	16.6	<0.100	0.628
HFG1-10-SSM-S	3	1	18	S-11773LM21	3.21	2.49	<0.100	<0.100	0.570	<0.100	14.7	<0.100	0.516
LRM	3	1	19	LRMLM313	5.01	0.338	0.141	0.961	1.22	<0.100	15.3	0.191	0.0946
ARG-1	3	1	20	ARGLM313	2.45	1.10	<0.100	9.36	2.22	1.42	8.35	0.105	<0.0500
LRM	3	2	1	LRMLM321	4.89	0.362	0.143	0.941	1.16	<0.100	14.9	0.200	0.0778
ARG-1	3	2	2	ARG1LM321	2.42	1.10	<0.100	9.24	2.13	1.42	8.21	0.110	<0.0500

Table A-1. Measurements of the Samples Prepared by LM in Analytical Sequence (continued)

Glass ID	Block	Sub - Block	Seq	Lab ID	Al (wt.%)	Ca (wt.%)	Cr (wt.%)	Fe (wt.%)	K (wt.%)	Mn (wt.%)	Na (wt.%)	P (wt.%)	S (wt.%)
HFG1-10-SSM-S	3	2	3	S-11773LM12	3.26	2.54	<0.100	<0.100	0.637	<0.100	14.3	<0.100	0.496
HFG1-06-SSM-S	3	2	4	S-11769LM22	2.88	1.05	<0.100	0.150	0.983	<0.100	16.7	<0.100	0.668
HFG1-08-SSM-S	3	2	5	S-11771LM12	1.72	3.19	<0.100	0.276	1.06	0.143	16.4	<0.100	0.496
HFG1-08-SSM-S	3	2	6	S-11771LM22	1.71	3.17	<0.100	0.272	1.04	0.141	16.5	<0.100	0.480
HFG1-10-SSM-S	3	2	7	S-11773LM22	3.21	2.50	<0.100	<0.100	0.617	<0.100	14.3	<0.100	0.531
HFG1-07-SSM-S	3	2	8	S-11770LM12	5.09	<0.100	<0.100	<0.100	1.01	<0.100	13.4	<0.100	0.290
HFG1-17-SSM-S	3	2	9	S-11780LM22	2.57	2.80	<0.100	0.123	0.156	<0.100	13.0	<0.100	0.580
LRM	3	2	10	LRMLM322	5.04	0.359	0.142	0.956	1.21	<0.100	15.0	0.199	0.0847
ARG-1	3	2	11	ARG1LM322	2.46	1.11	<0.100	9.34	2.20	1.43	8.29	0.110	<0.0500
HFG1-17-SSM-S	3	2	12	S-11780LM12	2.54	2.77	<0.100	0.125	0.160	<0.100	13.0	<0.100	0.582
HFG1-14-SSM-S	3	2	13	S-11777LM12	1.35	4.27	<0.100	<0.100	0.110	<0.100	15.9	<0.100	0.671
HFG1-01-1-SSM-S	3	2	14	S-11764LM22	5.04	0.568	<0.100	0.142	1.11	<0.100	10.8	<0.100	0.364
HFG1-06-SSM-S	3	2	15	S-11769LM12	2.85	1.04	<0.100	0.146	0.951	<0.100	17.0	<0.100	0.644
HFG1-07-SSM-S	3	2	16	S-11770LM22	5.09	<0.100	<0.100	<0.100	0.970	<0.100	13.5	<0.100	0.284
HFG1-01-1-SSM-S	3	2	17	S-11764LM12	5.04	0.574	<0.100	0.143	1.10	<0.100	10.5	<0.100	0.362
HFG1-14-SSM-S	3	2	18	S-11777LM22	1.33	4.21	<0.100	<0.100	0.101	<0.100	15.9	<0.100	0.653
LRM	3	2	19	LRMLM323	4.93	0.358	0.142	0.942	1.17	<0.100	14.8	0.199	0.0825
ARG-1	3	2	20	ARG1LM323	2.38	1.08	<0.100	9.15	2.10	1.40	8.41	0.107	<0.0500

Table A-2. Measurements of the Samples Prepared by PF in Analytical Sequence

Glass ID	Block	Sub - Block	Seq	Lab ID	B (wt.%)	Li (wt.%)	Si (wt.%)	Zn (wt.%)	Zr (wt.%)
LRM	1	1	1	LRMPF111	2.15	<0.100	23.9	<0.100	0.648
ARG-1	1	1	2	ARG1PF111	2.31	1.54	21.0	<0.100	<0.100
HFG1-09-SSM-S	1	1	3	S-11772PF11	1.15	1.62	20.4	3.13	2.90
HFG1-07-SSM-S	1	1	4	S-11770PF21	3.28	0.208	22.2	0.820	3.29
HFG1-16-SSM-S	1	1	5	S-11779PF11	1.07	2.56	16.9	<0.100	8.19
HFG1-20-SSM-S	1	1	6	S-11783PF21	1.20	1.93	18.8	2.99	4.71
HFG1-12-SSM-S	1	1	7	S-11775PF11	1.93	2.04	21.7	0.107	8.21
HFG1-12-SSM-S	1	1	8	S-11775PF21	1.98	2.01	22.1	0.113	8.41
HFG1-07-SSM-S	1	1	9	S-11770PF11	3.46	0.214	22.3	0.838	3.40
LRM	1	1	10	LRMPF112	2.28	<0.100	24.7	<0.100	0.660
ARG-1	1	1	11	ARGPF112	2.42	1.52	21.4	<0.100	<0.100
HFG1-19-SSM-S	1	1	12	S-11782PF11	2.44	0.599	18.2	2.43	3.87
HFG1-19-SSM-S	1	1	13	S-11782PF21	2.40	0.559	18.1	2.44	3.89
HFG1-09-SSM-S	1	1	14	S-11772PF21	1.17	1.61	22.1	3.14	2.90
HFG1-20-SSM-S	1	1	15	S-11783PF11	1.24	1.84	19.1	3.05	4.75
HFG1-04-SSM-S	1	1	16	S-11767PF11	2.73	0.299	21.2	2.64	3.26
HFG1-16-SSM-S	1	1	17	S-11779PF21	1.14	2.69	17.3	<0.100	8.55
HFG1-04-SSM-S	1	1	18	S-11767PF21	2.81	0.305	21.3	2.67	3.35
LRM	1	1	19	LRMPF113	2.31	<0.100	25.0	<0.100	0.674
ARG-1	1	1	20	ARGPF113	2.49	1.54	21.7	<0.100	<0.100
LRM	1	2	1	LRMPF121	2.41	<0.100	25.3	<0.100	0.683
ARG-1	1	2	2	ARG1PF121	2.56	1.60	21.8	<0.100	<0.100
HFG1-19-SSM-S	1	2	3	S-11782PF12	2.53	0.625	18.5	2.52	4.02
HFG1-04-SSM-S	1	2	4	S-11767PF22	2.78	0.308	21.1	2.74	3.29
HFG1-09-SSM-S	1	2	5	S-11772PF12	1.35	1.68	21.8	3.33	3.04
HFG1-07-SSM-S	1	2	6	S-11770PF12	3.60	0.220	23.1	0.881	3.49
HFG1-20-SSM-S	1	2	7	S-11783PF22	1.42	2.04	19.4	3.19	4.93
HFG1-16-SSM-S	1	2	8	S-11779PF12	1.32	2.78	17.7	<0.100	8.84
HFG1-19-SSM-S	1	2	9	S-11782PF22	2.55	0.598	18.7	2.58	4.14
LRM	1	2	10	LRMPF122	2.42	<0.100	25.1	<0.100	0.691
ARG-1	1	2	11	ARGPF122	2.60	1.59	21.9	<0.100	<0.100
HFG1-09-SSM-S	1	2	12	S-11772PF22	1.36	1.70	22.6	3.29	3.01
HFG1-12-SSM-S	1	2	13	S-11775PF22	2.13	2.10	22.7	0.119	8.72
HFG1-12-SSM-S	1	2	14	S-11775PF12	2.13	2.18	22.2	0.116	8.67
HFG1-04-SSM-S	1	2	15	S-11767PF12	2.82	0.312	21.4	2.74	3.35
HFG1-16-SSM-S	1	2	16	S-11779PF22	1.31	2.80	17.6	<0.100	8.78
HFG1-20-SSM-S	1	2	17	S-11783PF12	1.38	1.95	19.6	3.20	5.00
HFG1-07-SSM-S	1	2	18	S-11770PF22	3.54	0.220	22.9	0.875	3.52
LRM	1	2	19	LRMPF123	2.40	<0.100	25.0	<0.100	0.686
ARG-1	1	2	20	ARGPF123	2.53	1.58	21.8	<0.100	<0.100
LRM	2	1	1	LRMPF211	2.30	<0.100	24.7	<0.100	0.664
ARG-1	2	1	2	ARG1PF211	2.52	1.69	21.8	<0.100	<0.100
HFG1-10-SSM-S	2	1	3	S-11773PF21	3.15	1.44	17.5	3.23	9.77
HFG1-13-SSM-S	2	1	4	S-11776PF21	2.54	2.87	23.2	1.46	3.34
HFG1-06-SSM-S	2	1	5	S-11769PF21	1.85	1.77	21.5	0.368	5.27
HFG1-18-SSM-S	2	1	6	S-11781PF11	3.69	2.36	24.5	1.91	5.14
HFG1-13-SSM-S	2	1	7	S-11776PF11	2.50	2.86	23.0	1.41	3.25
HFG1-18-SSM-S	2	1	8	S-11781PF21	3.62	2.40	24.0	1.91	5.07
HFG1-15-SSM-S	2	1	9	S-11778PF21	2.59	2.02	23.5	0.450	4.54

Table A-2. Measurements of the Samples Prepared by PF in Analytical Sequence (continued)

Glass ID	Block	Sub - Block	Seq	Lab ID	B (wt.%)	Li (wt.%)	Si (wt.%)	Zn (wt.%)	Zr (wt.%)
LRM	2	1	10	LRMPF212	2.38	<0.100	25.3	<0.100	0.713
ARG-1	2	1	11	ARGPF212	2.62	1.68	22.1	<0.100	<0.100
HFG1-10-SSM-S	2	1	12	S-11773PF11	3.24	1.47	17.7	3.28	9.87
HFG1-03-SSM-S	2	1	13	S-11766PF21	2.55	<0.100	22.8	2.63	7.55
HFG1-15-SSM-S	2	1	14	S-11778PF11	2.51	1.91	22.6	0.428	4.39
HFG1-06-SSM-S	2	1	15	S-11769PF11	1.80	1.71	21.5	0.362	5.17
HFG1-03-SSM-S	2	1	16	S-11766PF11	2.54	<0.100	22.4	2.56	7.42
HFG1-17-SSM-S	2	1	17	S-11780PF11	1.21	2.63	21.0	2.23	9.21
HFG1-17-SSM-S	2	1	18	S-11780PF21	1.20	2.61	20.6	2.21	9.12
LRM	2	1	19	LRMPF213	2.44	<0.100	25.4	<0.100	0.780
ARG-1	2	1	20	ARGPF213	2.61	1.69	22.3	<0.100	<0.100
LRM	2	2	1	LRMPF221	2.40	<0.100	25.7	<0.100	0.688
ARG-1	2	2	2	ARG1PF221	2.57	1.63	22.4	<0.100	<0.100
HFG1-18-SSM-S	2	2	3	S-11781PF22	3.70	2.36	24.8	1.92	5.23
HFG1-18-SSM-S	2	2	4	S-11781PF12	3.71	2.28	24.9	1.93	5.27
HFG1-03-SSM-S	2	2	5	S-11766PF12	2.49	<0.100	22.4	2.53	7.47
HFG1-10-SSM-S	2	2	6	S-11773PF12	3.19	1.39	17.6	3.20	9.95
HFG1-15-SSM-S	2	2	7	S-11778PF12	2.52	1.84	23.0	0.420	4.48
HFG1-13-SSM-S	2	2	8	S-11776PF22	2.59	2.76	23.7	1.46	3.42
HFG1-13-SSM-S	2	2	9	S-11776PF12	2.55	2.78	23.8	1.42	3.35
LRM	2	2	10	LRMPF222	2.42	<0.100	25.9	<0.100	0.699
ARG-1	2	2	11	ARGPF222	2.61	1.63	22.5	<0.100	<0.100
HFG1-17-SSM-S	2	2	12	S-11780PF22	1.20	2.50	20.6	2.18	9.14
HFG1-06-SSM-S	2	2	13	S-11769PF22	1.87	1.69	22.0	0.361	5.40
HFG1-10-SSM-S	2	2	14	S-11773PF22	3.22	1.37	17.7	3.23	9.97
HFG1-06-SSM-S	2	2	15	S-11769PF12	1.83	1.66	21.5	0.358	5.29
HFG1-15-SSM-S	2	2	16	S-11778PF22	2.69	1.99	24.4	0.452	4.70
HFG1-17-SSM-S	2	2	17	S-11780PF12	1.22	2.60	21.6	2.26	9.50
HFG1-03-SSM-S	2	2	18	S-11766PF22	2.54	<0.100	23.0	2.62	7.69
LRM	2	2	19	LRMPF223	2.39	<0.100	25.7	<0.100	0.751
ARG-1	2	2	20	ARGPF223	2.57	1.61	22.0	<0.100	<0.100
LRM	3	1	1	LRMPF311	2.27	<0.100	24.4	<0.100	0.659
ARG-1	3	1	2	ARG1PF311	2.47	1.60	21.2	<0.100	<0.100
HFG1-14-SSM-S	3	1	3	S-11777PF21	1.39	0.737	20.8	1.06	5.58
HFG1-11-SSM-S	3	1	4	S-11774PF11	2.80	0.661	18.7	1.99	8.66
HFG1-05-SSM-S	3	1	5	S-11768PF21	2.79	1.30	19.9	0.567	7.80
HFG1-08-SSM-S	3	1	6	S-11771PF11	1.33	0.233	18.6	0.776	8.80
HFG1-01-1-SSM-S	3	1	7	S-11764PF21	2.06	2.67	20.5	2.77	5.78
HFG1-05-SSM-S	3	1	8	S-11768PF11	2.85	1.35	20.0	0.584	7.90
HFG1-11-SSM-S	3	1	9	S-11774PF21	2.84	0.676	19.1	2.01	8.86
LRM	3	1	10	LRMPF312	2.29	<0.100	24.5	<0.100	0.718
ARG-1	3	1	11	ARGPF312	2.45	1.57	20.9	<0.100	<0.100
EWG-HFG1-SSM-S	3	1	12	S-11784PF11	3.53	2.39	20.9	1.17	1.36
HFG1-01-1-SSM-S	3	1	13	S-11764PF11	2.10	2.49	20.6	2.79	5.79
HFG1-14-SSM-S	3	1	14	S-11777PF11	1.44	0.752	21.7	1.07	5.67
HFG1-02-SSM-S	3	1	15	S-11765PF11	1.76	0.712	25.0	1.10	3.07
EWG-HFG1-SSM-S	3	1	16	S-11784PF21	3.61	2.13	21.5	1.23	1.40
HFG1-02-SSM-S	3	1	17	S-11765PF21	1.79	0.715	25.5	1.12	3.09
HFG1-08-SSM-S	3	1	18	S-11771PF21	1.34	0.237	19.2	0.799	8.92

Table A-2. Measurements of the Samples Prepared by PF in Analytical Sequence (continued)

Glass ID	Block	Sub - Block	Seq	Lab ID	B (wt.%)	Li (wt.%)	Si (wt.%)	Zn (wt.%)	Zr (wt.%)
LRM	3	1	19	LRMPF313	2.29	<0.100	24.7	<0.100	0.699
ARG-1	3	1	20	ARGPF313	2.50	1.60	21.3	<0.100	<0.100
LRM	3	2	1	LRMPF321	2.36	<0.100	25.1	<0.100	0.669
ARG-1	3	2	2	ARG1PF321	2.55	1.58	21.5	<0.100	<0.100
EWG-HFG1-SSM-S	3	2	3	S-11784PF12	3.56	2.38	20.9	1.18	1.38
HFG1-05-SSM-S	3	2	4	S-11768PF12	2.93	1.34	20.3	0.594	8.08
HFG1-01-1-SSM-S	3	2	5	S-11764PF12	2.12	2.49	20.9	2.85	6.00
HFG1-08-SSM-S	3	2	6	S-11771PF12	1.36	0.227	18.7	0.789	8.93
HFG1-11-SSM-S	3	2	7	S-11774PF22	2.90	0.659	19.1	2.05	8.99
HFG1-05-SSM-S	3	2	8	S-11768PF22	2.88	1.30	20.3	0.578	8.06
HFG1-02-SSM-S	3	2	9	S-11765PF12	1.81	0.705	25.2	1.12	3.24
LRM	3	2	10	LRMPF322	2.37	<0.100	25.1	<0.100	0.690
ARG-1	3	2	11	ARGPF322	2.54	1.59	21.8	<0.100	<0.100
HFG1-01-1-SSM-S	3	2	12	S-11764PF22	2.06	2.61	20.3	2.78	5.80
HFG1-11-SSM-S	3	2	13	S-11774PF12	2.83	0.652	18.9	2.02	8.82
HFG1-02-SSM-S	3	2	14	S-11765PF22	1.80	0.703	25.4	1.12	3.18
HFG1-14-SSM-S	3	2	15	S-11777PF22	1.44	0.737	21.5	1.07	5.78
HFG1-14-SSM-S	3	2	16	S-11777PF12	1.45	0.734	21.9	1.07	5.75
EWG-HFG1-SSM-S	3	2	17	S-11784PF22	3.61	2.09	21.7	1.24	1.43
HFG1-08-SSM-S	3	2	18	S-11771PF22	1.39	0.238	19.4	0.818	9.25
LRM	3	2	19	LRMPF323	2.31	<0.100	25.0	<0.100	0.709
ARG-1	3	2	20	ARGPF323	2.49	1.57	21.2	<0.100	<0.100

Table A-3. Measurements of the Samples Prepared by KH in Analytical Sequence

PNNL ID	Block	Sub - Block	Seq	Lab ID	Fluoride (wt.%)
LRM	1	1	1	LRMKH111	0.886
HFG1-10-SSM-S	1	1	2	S-11773KH21	3.01
HFG1-16-SSM-S	1	1	3	S-11779KH11	1.78
HFG1-13-SSM-S	1	1	4	S-11776KH11	2.87
HFG1-19-SSM-S	1	1	5	S-11782KH11	3.78
HFG1-14-SSM-S	1	1	6	S-11777KH21	3.17
HFG1-18-SSM-S	1	1	7	S-11781KH21	2.33
HFG1-15-SSM-S	1	1	8	S-11778KH21	1.45
LRM	1	1	9	LRMKH112	0.881
HFG1-13-SSM-S	1	1	10	S-11776KH21	2.88
HFG1-10-SSM-S	1	1	11	S-11773KH11	3.00
HFG1-16-SSM-S	1	1	12	S-11779KH21	1.78
HFG1-14-SSM-S	1	1	13	S-11777KH11	3.13
HFG1-18-SSM-S	1	1	14	S-11781KH11	2.18
HFG1-15-SSM-S	1	1	15	S-11778KH11	1.45
HFG1-19-SSM-S	1	1	16	S-11782KH21	3.76
LRM	1	1	17	LRMKH113	0.913
LRM	1	2	1	LRMKH121	0.863
HFG1-16-SSM-S	1	2	2	S-11779KH12	1.78
HFG1-15-SSM-S	1	2	3	S-11778KH12	1.45
HFG1-18-SSM-S	1	2	4	S-11781KH22	2.33
HFG1-16-SSM-S	1	2	5	S-11779KH22	1.79
HFG1-15-SSM-S	1	2	6	S-11778KH22	1.45
HFG1-14-SSM-S	1	2	7	S-11777KH22	3.15
HFG1-10-SSM-S	1	2	8	S-11773KH22	3.04
LRM	1	2	9	LRMKH122	0.892
HFG1-10-SSM-S	1	2	10	S-11773KH12	2.93
HFG1-19-SSM-S	1	2	11	S-11782KH12	3.69
HFG1-14-SSM-S	1	2	12	S-11777KH12	3.08
HFG1-13-SSM-S	1	2	13	S-11776KH22	2.82
HFG1-19-SSM-S	1	2	14	S-11782KH22	3.70
HFG1-13-SSM-S	1	2	15	S-11776KH12	2.81
HFG1-18-SSM-S	1	2	16	S-11781KH12	2.13
LRM	1	2	17	LRMKH123	0.849
LRM	2	1	1	LRMKH211	0.854
HFG1-01-1-SSM-S	2	1	2	S-11764KH11	3.31
HFG1-01-1-SSM-S	2	1	3	S-11764KH21	3.31
HFG1-09-SSM-S	2	1	4	S-11772KH11	4.53
HFG1-04-SSM-S	2	1	5	S-11767KH11	2.07
HFG1-20-SSM-S	2	1	6	S-11783KH21	2.12
HFG1-04-SSM-S	2	1	7	S-11767KH21	2.10
HFG1-07-SSM-S	2	1	8	S-11770KH21	2.70
LRM	2	1	9	LRMKH212	0.863
HFG1-09-SSM-S	2	1	10	S-11772KH21	4.50
HFG1-06-SSM-S	2	1	11	S-11769KH11	3.51
HFG1-20-SSM-S	2	1	12	S-11783KH11	2.09
HFG1-06-SSM-S	2	1	13	S-11769KH21	3.43
HFG1-08-SSM-S	2	1	14	S-11771KH21	4.39
HFG1-08-SSM-S	2	1	15	S-11771KH11	4.41
HFG1-07-SSM-S	2	1	16	S-11770KH11	2.69
LRM	2	1	17	LRMKH213	0.869

Table A-3. Measurements of the Samples Prepared by KH in Analytical Sequence (continued)

PNNL ID	Block	Sub - Block	Seq	Lab ID	Fluoride (wt.%)
LRM	2	2	1	LRMKH221	0.862
HFG1-07-SSM-S	2	2	2	S-11770KH12	2.72
HFG1-08-SSM-S	2	2	3	S-11771KH12	4.43
HFG1-08-SSM-S	2	2	4	S-11771KH22	4.48
HFG1-20-SSM-S	2	2	5	S-11783KH22	2.17
HFG1-20-SSM-S	2	2	6	S-11783KH12	2.17
HFG1-06-SSM-S	2	2	7	S-11769KH12	3.60
HFG1-09-SSM-S	2	2	8	S-11772KH22	4.66
LRM	2	2	9	LRMKH222	0.891
HFG1-07-SSM-S	2	2	10	S-11770KH22	2.77
HFG1-04-SSM-S	2	2	11	S-11767KH22	2.14
HFG1-04-SSM-S	2	2	12	S-11767KH12	2.15
HFG1-01-1-SSM-S	2	2	13	S-11764KH12	3.41
HFG1-06-SSM-S	2	2	14	S-11769KH22	3.54
HFG1-09-SSM-S	2	2	15	S-11772KH12	4.65
HFG1-01-1-SSM-S	2	2	16	S-11764KH22	2.78
LRM	2	2	17	LRMKH223	0.886
LRM	3	1	1	LRMKH311	0.881
HFG1-11-SSM-S	3	1	2	S-11774KH21	4.78
HFG1-17-SSM-S	3	1	3	S-11780KH21	1.92
HFG1-03-SSM-S	3	1	4	S-11766KH11	3.18
EWG-HFG1-SSM-S	3	1	5	S-11784KH11	<0.0250
EWG-HFG1-SSM-S	3	1	6	S-11784KH21	<0.0250
HFG1-05-SSM-S	3	1	7	S-11768KH21	2.32
HFG1-02-SSM-S	3	1	8	S-11765KH21	3.56
LRM	3	1	9	LRMKH312	0.880
HFG1-17-SSM-S	3	1	10	S-11780KH11	1.91
HFG1-02-SSM-S	3	1	11	S-11765KH11	3.52
HFG1-03-SSM-S	3	1	12	S-11766KH21	3.19
HFG1-12-SSM-S	3	1	13	S-11775KH21	4.43
HFG1-11-SSM-S	3	1	14	S-11774KH11	4.72
HFG1-12-SSM-S	3	1	15	S-11775KH11	4.38
HFG1-05-SSM-S	3	1	16	S-11768KH11	2.32
LRM	3	1	17	LRMKH313	0.871
LRM	3	2	1	LRMKH321	0.915
HFG1-02-SSM-S	3	2	2	S-11765KH12	3.78
HFG1-17-SSM-S	3	2	3	S-11780KH12	2.05
HFG1-11-SSM-S	3	2	4	S-11774KH22	4.93
HFG1-05-SSM-S	3	2	5	S-11768KH22	2.45
HFG1-11-SSM-S	3	2	6	S-11774KH12	4.98
EWG-HFG1-SSM-S	3	2	7	S-11784KH22	<0.0250
HFG1-03-SSM-S	3	2	8	S-11766KH12	3.36
LRM	3	2	9	LRMKH322	0.927
HFG1-02-SSM-S	3	2	10	S-11765KH22	3.63
HFG1-17-SSM-S	3	2	11	S-11780KH22	2.02
EWG-HFG1-SSM-S	3	2	12	S-11784KH12	<0.0250
HFG1-12-SSM-S	3	2	13	S-11775KH22	4.65
HFG1-12-SSM-S	3	2	14	S-11775KH12	4.62
HFG1-03-SSM-S	3	2	15	S-11766KH22	3.35
HFG1-05-SSM-S	3	2	16	S-11768KH12	2.46
LRM	3	2	17	LRMKH323	0.908

Table A-4. Comparison of Measured and Targeted Compositions

Glass ID	Oxide	Measured (wt.%)	Targeted (wt.%)	Difference of Measured versus Targeted (wt.%)	% Difference of Measured versus Targeted
ARG-1	Al_2O_3	4.67	4.73	-0.060	-1%
ARG-1	B_2O_3	8.12	8.67	-0.547	-6%
ARG-1	CaO	1.51	1.43	0.084	6%
ARG-1	Cr_2O_3	<0.146	0.093	0.053	
ARG-1	F				
ARG-1	Fe_2O_3	13.5	14	-0.477	-3%
ARG-1	K_2O	2.64	2.71	-0.066	-2%
ARG-1	Li_2O	3.45	3.21	0.236	7%
ARG-1	MnO	1.86	1.88	-0.025	-1%
ARG-1	Na_2O	11.2	11.5	-0.343	-3%
ARG-1	P_2O_5	<0.241	0.22	0.021	
ARG-1	SiO_2	46.4	47.9	-1.480	-3%
ARG-1	SO_3	<0.125	0	0.125	
ARG-1	ZnO	<0.124	0.02	0.104	
ARG-1	ZrO_2	<0.135	0.13	0.005	
ARG-1	**Sum Oxide**	**94.1**	**96.493**	**-2.370**	**-2%**
LRM	Al_2O_3	9.5	9.51	-0.008	0%
LRM	B_2O_3	7.55	7.85	-0.303	-4%
LRM	CaO	0.47	0.54	-0.070	
LRM	Cr_2O_3	0.203	0.19	0.013	
LRM	F	0.883	0.86	0.023	
LRM	Fe_2O_3	1.39	1.38	0.011	1%
LRM	K_2O	1.43	1.48	-0.045	-3%
LRM	Li_2O	<0.215	0.11	0.105	
LRM	MnO	<0.129	0.08	0.049	
LRM	Na_2O	20.1	20.03	0.085	0%
LRM	P_2O_5	0.438	0.54	-0.102	
LRM	SiO_2	53.5	54.2	-0.658	-1%
LRM	SO_3	0.229	0.3	-0.071	
LRM	ZnO	<0.124	0	0.124	
LRM	ZrO_2	0.937	0.93	0.007	
LRM	**Sum Oxide**	**97.2**	**98**	**-0.840**	**-1%**
EWG-HFG1-SSM-S	Al_2O_3	6.65	5.59	1.060	19%
EWG-HFG1-SSM-S	B_2O_3	11.5	11.3	0.219	2%
EWG-HFG1-SSM-S	CaO	2.33	2.23	0.096	4%
EWG-HFG1-SSM-S	Cr_2O_3	<0.146			
EWG-HFG1-SSM-S	F	<0.025			
EWG-HFG1-SSM-S	Fe_2O_3	<0.143			
EWG-HFG1-SSM-S	K_2O	<0.12			
EWG-HFG1-SSM-S	Li_2O	4.84	5.08	-0.241	-5%
EWG-HFG1-SSM-S	MnO	<0.129			
EWG-HFG1-SSM-S	Na_2O	9.32	9.67	-0.349	-4%
EWG-HFG1-SSM-S	P_2O_5	0.521	0.65	-0.129	
EWG-HFG1-SSM-S	SiO_2	45.5	46.5	-1.040	-2%
EWG-HFG1-SSM-S	SO_3	<0.125			
EWG-HFG1-SSM-S	ZnO	1.5	1.46	0.040	3%

Table A-4. Comparison of Measured and Targeted Compositions (continued)

Glass ID	Oxide	Measured (wt.%)	Targeted (wt.%)	Difference of Measured versus Targeted (wt.%)	% Difference of Measured versus Targeted
EWG-HFG1-SSM-S	ZrO_2	1.88	1.8	0.081	4%
EWG-HFG1-SSM-S	**Sum Oxide**	**84.7**	**84.28**	**0.427**	**1%**
HFG1-01-1-SSM-S	Al_2O_3	9.49	9.7	-0.205	-2%
HFG1-01-1-SSM-S	B_2O_3	6.71	6.973	-0.260	-4%
HFG1-01-1-SSM-S	CaO	0.76	0.826	-0.066	
HFG1-01-1-SSM-S	Cr_2O_3	<0.146	0.091	0.055	
HFG1-01-1-SSM-S	F	3.2	5.322	-2.120	-40%
HFG1-01-1-SSM-S	Fe_2O_3	0.2	0.182	0.018	
HFG1-01-1-SSM-S	K_2O	1.34	1.554	-0.217	-14%
HFG1-01-1-SSM-S	Li_2O	5.52	5.594	-0.072	-1%
HFG1-01-1-SSM-S	MnO	<0.129	0.091	0.038	
HFG1-01-1-SSM-S	Na_2O	14.4	13.834	0.590	4%
HFG1-01-1-SSM-S	P_2O_5	<0.229	0.137	0.092	
HFG1-01-1-SSM-S	SiO_2	44	43.738	0.278	1%
HFG1-01-1-SSM-S	SO_3	0.891	0.182	0.709	
HFG1-01-1-SSM-S	ZnO	3.48	3.471	0.011	0%
HFG1-01-1-SSM-S	ZrO_2	7.89	8.305	-0.413	-5%
HFG1-01-1-SSM-S	**Sum Oxide**	**98.4**	**100**	**-1.560**	**-2%**
HFG1-02-SSM-S	Al_2O_3	8.21	7.942	0.263	3%
HFG1-02-SSM-S	B_2O_3	5.76	5.87	-0.106	-2%
HFG1-02-SSM-S	CaO	2.7	2.795	-0.095	-3%
HFG1-02-SSM-S	Cr_2O_3	<0.146	0.085	0.061	
HFG1-02-SSM-S	F	3.62	6.007	-2.380	-40%
HFG1-02-SSM-S	Fe_2O_3	0.197	0.171	0.026	
HFG1-02-SSM-S	K_2O	0.98	1.001	-0.021	-2%
HFG1-02-SSM-S	Li_2O	1.53	1.758	-0.232	-13%
HFG1-02-SSM-S	MnO	<0.129	0.085	0.044	
HFG1-02-SSM-S	Na_2O	15.3	15.53	-0.264	-2%
HFG1-02-SSM-S	P_2O_5	<0.229	0.128	0.101	
HFG1-02-SSM-S	SiO_2	54.1	52.836	1.230	2%
HFG1-02-SSM-S	SO_3	0.795	0.171	0.624	
HFG1-02-SSM-S	ZnO	1.39	1.333	0.055	4%
HFG1-02-SSM-S	ZrO_2	4.25	4.289	-0.041	-1%
HFG1-02-SSM-S	**Sum Oxide**	**99.3**	**100.001**	**-0.735**	**-1%**
HFG1-03-SSM-S	Al_2O_3	3.95	3.863	0.086	2%
HFG1-03-SSM-S	B_2O_3	8.15	8.435	-0.289	-3%
HFG1-03-SSM-S	CaO	2.14	2.191	-0.054	-2%
HFG1-03-SSM-S	Cr_2O_3	<0.146	0.079	0.067	
HFG1-03-SSM-S	F	3.27	5.231	-1.960	-37%
HFG1-03-SSM-S	Fe_2O_3	0.18	0.158	0.022	
HFG1-03-SSM-S	K_2O	0.727	0.763	-0.036	
HFG1-03-SSM-S	Li_2O	<0.215	0.057	0.158	
HFG1-03-SSM-S	MnO	<0.129	0.079	0.050	
HFG1-03-SSM-S	Na_2O	15.5	16.652	-1.190	-7%
HFG1-03-SSM-S	P_2O_5	<0.229	0.118	0.111	
HFG1-03-SSM-S	SiO_2	48.5	48.259	0.196	0%
HFG1-03-SSM-S	SO_3	0.695	0.158	0.537	

Table A-4. Comparison of Measured and Targeted Compositions (continued)

Glass ID	Oxide	Measured (wt.%)	Targeted (wt.%)	Difference of Measured versus Targeted (wt.%)	% Difference of Measured versus Targeted
HFG1-03-SSM-S	ZnO	3.22	3.226	-0.008	0%
HFG1-03-SSM-S	ZrO_2	10.2	10.733	-0.558	-5%
HFG1-03-SSM-S	**Sum Oxide**	**97.1**	**100.002**	**-2.860**	**-3%**
HFG1-04-SSM-S	Al_2O_3	1.87	1.884	-0.017	-1%
HFG1-04-SSM-S	B_2O_3	8.97	9.263	-0.296	-3%
HFG1-04-SSM-S	CaO	5.41	5.393	0.022	0%
HFG1-04-SSM-S	Cr_2O_3	<0.146	0.128	0.018	
HFG1-04-SSM-S	F	2.12	3.096	-0.981	-32%
HFG1-04-SSM-S	Fe_2O_3	0.274	0.256	0.018	
HFG1-04-SSM-S	K_2O	1.23	1.497	-0.268	-18%
HFG1-04-SSM-S	Li_2O	0.659	0.664	-0.005	
HFG1-04-SSM-S	MnO	<0.129	0.128	0.001	
HFG1-04-SSM-S	Na_2O	22.6	23.277	-0.698	-3%
HFG1-04-SSM-S	P_2O_5	<0.229	0.192	0.037	
HFG1-04-SSM-S	SiO_2	45.5	45.88	-0.420	-1%
HFG1-04-SSM-S	SO_3	2.12	0.256	1.870	729%
HFG1-04-SSM-S	ZnO	3.36	3.366	-0.008	0%
HFG1-04-SSM-S	ZrO_2	4.47	4.72	-0.245	-5%
HFG1-04-SSM-S	**Sum Oxide**	**99**	**100**	**-0.975**	**-1%**
HFG1-05-SSM-S	Al_2O_3	3.93	3.808	0.127	3%
HFG1-05-SSM-S	B_2O_3	9.22	9.734	-0.517	-5%
HFG1-05-SSM-S	CaO	0.338	0.303	0.035	
HFG1-05-SSM-S	Cr_2O_3	<0.147	0.193	-0.047	
HFG1-05-SSM-S	F	2.39	3.773	-1.390	-37%
HFG1-05-SSM-S	Fe_2O_3	0.404	0.387	0.017	
HFG1-05-SSM-S	K_2O	0.242	0.244	-0.002	
HFG1-05-SSM-S	Li_2O	2.85	2.668	0.179	7%
HFG1-05-SSM-S	MnO	0.2	0.193	0.007	
HFG1-05-SSM-S	Na_2O	21	22.362	-1.330	-6%
HFG1-05-SSM-S	P_2O_5	<0.23	0.29	-0.060	
HFG1-05-SSM-S	SiO_2	43.1	43.486	-0.433	-1%
HFG1-05-SSM-S	SO_3	1.44	0.387	1.060	273%
HFG1-05-SSM-S	ZnO	0.723	0.72	0.003	
HFG1-05-SSM-S	ZrO_2	10.8	11.452	-0.700	-6%
HFG1-05-SSM-S	**Sum Oxide**	**96.9**	**100**	**-3.050**	**-3%**
HFG1-06-SSM-S	Al_2O_3	5.42	5.564	-0.141	-3%
HFG1-06-SSM-S	B_2O_3	5.92	6.076	-0.159	-3%
HFG1-06-SSM-S	CaO	1.46	1.368	0.091	7%
HFG1-06-SSM-S	Cr_2O_3	<0.146	0.106	0.040	
HFG1-06-SSM-S	F	3.52	5.056	-1.540	-30%
HFG1-06-SSM-S	Fe_2O_3	0.209	0.212	-0.003	
HFG1-06-SSM-S	K_2O	1.12	1.174	-0.051	-4%
HFG1-06-SSM-S	Li_2O	3.68	3.415	0.261	8%
HFG1-06-SSM-S	MnO	<0.129	0.106	0.023	
HFG1-06-SSM-S	Na_2O	22.7	22.984	-0.304	-1%
HFG1-06-SSM-S	P_2O_5	<0.229	0.159	0.070	

Table A-4. Comparison of Measured and Targeted Compositions (continued)

Glass ID	Oxide	Measured (wt.%)	Targeted (wt.%)	Difference of Measured versus Targeted (wt.%)	% Difference of Measured versus Targeted
HFG1-06-SSM-S	SiO_2	46.3	45.732	0.530	1%
HFG1-06-SSM-S	SO_3	1.61	0.212	1.400	661%
HFG1-06-SSM-S	ZnO	0.451	0.446	0.005	
HFG1-06-SSM-S	ZrO_2	7.14	7.392	-0.256	-3%
HFG1-06-SSM-S	**Sum Oxide**	**100**	**100.002**	**-0.030**	**0%**
HFG1-07-SSM-S	Al_2O_3	9.48	9.919	-0.443	-4%
HFG1-07-SSM-S	B_2O_3	11.2	11.383	-0.210	-2%
HFG1-07-SSM-S	CaO	<0.14	0.042	0.098	
HFG1-07-SSM-S	Cr_2O_3	<0.146	0.042	0.104	
HFG1-07-SSM-S	F	2.72	4.376	-1.660	-38%
HFG1-07-SSM-S	Fe_2O_3	<0.143	0.084	0.059	
HFG1-07-SSM-S	K_2O	1.19	1.263	-0.074	-6%
HFG1-07-SSM-S	Li_2O	0.464	0.497	-0.033	
HFG1-07-SSM-S	MnO	<0.129	0.042	0.087	
HFG1-07-SSM-S	Na_2O	18.2	18.857	-0.659	-3%
HFG1-07-SSM-S	P_2O_5	<0.229	0.063	0.166	
HFG1-07-SSM-S	SiO_2	48.4	47.5	0.902	2%
HFG1-07-SSM-S	SO_3	0.728	0.084	0.644	
HFG1-07-SSM-S	ZnO	1.06	1.038	0.024	2%
HFG1-07-SSM-S	ZrO_2	4.63	4.812	-0.186	-4%
HFG1-07-SSM-S	**Sum Oxide**	**98.8**	**100.002**	**-1.180**	**-1%**
HFG1-08-SSM-S	Al_2O_3	3.22	3.079	0.143	5%
HFG1-08-SSM-S	B_2O_3	4.36	4.531	-0.168	-4%
HFG1-08-SSM-S	CaO	4.4	4.168	0.236	6%
HFG1-08-SSM-S	Cr_2O_3	<0.146	0.18	-0.034	
HFG1-08-SSM-S	F	4.43	6.523	-2.100	-32%
HFG1-08-SSM-S	Fe_2O_3	0.393	0.36	0.033	
HFG1-08-SSM-S	K_2O	1.24	1.343	-0.103	-8%
HFG1-08-SSM-S	Li_2O	0.503	0.463	0.040	
HFG1-08-SSM-S	MnO	0.184	0.18	0.004	
HFG1-08-SSM-S	Na_2O	22.5	23.412	-0.900	-4%
HFG1-08-SSM-S	P_2O_5	<0.229	0.27	-0.041	
HFG1-08-SSM-S	SiO_2	40.6	41.598	-1.000	-2%
HFG1-08-SSM-S	SO_3	1.21	0.36	0.852	237%
HFG1-08-SSM-S	ZnO	0.99	0.953	0.037	
HFG1-08-SSM-S	ZrO_2	12.1	12.58	-0.457	-4%
HFG1-08-SSM-S	**Sum Oxide**	**96.5**	**100**	**-3.460**	**-3%**
HFG1-09-SSM-S	Al_2O_3	5.97	5.755	0.216	4%
HFG1-09-SSM-S	B_2O_3	4.05	4.304	-0.255	-6%
HFG1-09-SSM-S	CaO	5.28	5.262	0.020	0%
HFG1-09-SSM-S	Cr_2O_3	<0.146	0.183	-0.037	
HFG1-09-SSM-S	F	4.59	6.761	-2.180	-32%
HFG1-09-SSM-S	Fe_2O_3	0.408	0.365	0.043	
HFG1-09-SSM-S	K_2O	0.352	0.359	-0.007	
HFG1-09-SSM-S	Li_2O	3.56	3.823	-0.265	-7%
HFG1-09-SSM-S	MnO	0.194	0.183	0.011	
HFG1-09-SSM-S	Na_2O	17.2	17.422	-0.235	-1%

Table A-4. Comparison of Measured and Targeted Compositions (continued)

Glass ID	Oxide	Measured (wt.%)	Targeted (wt.%)	Difference of Measured versus Targeted (wt.%)	% Difference of Measured versus Targeted
HFG1-09-SSM-S	P_2O_5	<0.23	0.274	-0.044	
HFG1-09-SSM-S	SiO_2	46.5	46.894	-0.418	-1%
HFG1-09-SSM-S	SO_3	1.52	0.365	1.160	318%
HFG1-09-SSM-S	ZnO	4.01	3.896	0.115	3%
HFG1-09-SSM-S	ZrO_2	4	4.156	-0.154	-4%
HFG1-09-SSM-S	**Sum Oxide**	**98**	**100.002**	**-2.030**	**-2%**
HFG1-10-SSM-S	Al_2O_3	6.09	6.204	-0.115	-2%
HFG1-10-SSM-S	B_2O_3	10.3	10.087	0.217	2%
HFG1-10-SSM-S	CaO	3.5	3.353	0.152	5%
HFG1-10-SSM-S	Cr_2O_3	<0.146	0.027	0.119	
HFG1-10-SSM-S	F	3	4.255	-1.260	-30%
HFG1-10-SSM-S	Fe_2O_3	<0.143	0.054	0.089	
HFG1-10-SSM-S	K_2O	0.728	0.812	-0.084	
HFG1-10-SSM-S	Li_2O	3.05	2.846	0.206	7%
HFG1-10-SSM-S	MnO	<0.129	0.027	0.102	
HFG1-10-SSM-S	Na_2O	19.5	19.718	-0.206	-1%
HFG1-10-SSM-S	P_2O_5	<0.229	0.04	0.189	
HFG1-10-SSM-S	SiO_2	37.7	35.312	2.390	7%
HFG1-10-SSM-S	SO_3	1.27	0.054	1.210	2244%
HFG1-10-SSM-S	ZnO	4.03	3.851	0.176	5%
HFG1-10-SSM-S	ZrO_2	13.4	13.36	-0.001	0%
HFG1-10-SSM-S	**Sum Oxide**	**103**	**100**	**3.190**	**3%**
HFG1-11-SSM-S	Al_2O_3	7.79	7.773	0.021	0%
HFG1-11-SSM-S	B_2O_3	9.15	9.465	-0.312	-3%
HFG1-11-SSM-S	CaO	<0.14	0.08	0.060	
HFG1-11-SSM-S	Cr_2O_3	<0.146	0.169	-0.023	
HFG1-11-SSM-S	F	4.85	6.968	-2.120	-30%
HFG1-11-SSM-S	Fe_2O_3	0.352	0.337	0.015	
HFG1-11-SSM-S	K_2O	0.866	0.897	-0.031	
HFG1-11-SSM-S	Li_2O	1.43	1.484	-0.059	-4%
HFG1-11-SSM-S	MnO	0.171	0.169	0.002	
HFG1-11-SSM-S	Na_2O	17.3	17.683	-0.395	-2%
HFG1-11-SSM-S	P_2O_5	<0.229	0.253	-0.024	
HFG1-11-SSM-S	SiO_2	40.5	39.54	1.000	3%
HFG1-11-SSM-S	SO_3	0.717	0.337	0.380	
HFG1-11-SSM-S	ZnO	2.51	2.463	0.048	2%
HFG1-11-SSM-S	ZrO_2	11.9	12.384	-0.453	-4%
HFG1-11-SSM-S	**Sum Oxide**	**98.1**	**100.002**	**-1.890**	**-2%**
HFG1-12-SSM-S	Al_2O_3	2.84	2.737	0.102	4%
HFG1-12-SSM-S	B_2O_3	6.58	6.902	-0.325	-5%
HFG1-12-SSM-S	CaO	5.89	5.939	-0.045	-1%
HFG1-12-SSM-S	Cr_2O_3	<0.146	0.032	0.114	
HFG1-12-SSM-S	F	4.52	6.699	-2.180	-33%
HFG1-12-SSM-S	Fe_2O_3	<0.143	0.065	0.078	
HFG1-12-SSM-S	K_2O	0.612	0.642	-0.030	
HFG1-12-SSM-S	Li_2O	4.48	4.75	-0.267	-6%
HFG1-12-SSM-S	MnO	<0.129	0.032	0.097	

Table A-4. Comparison of Measured and Targeted Compositions (continued)

Glass ID	Oxide	Measured (wt.%)	Targeted (wt.%)	Difference of Measured versus Targeted (wt.%)	% Difference of Measured versus Targeted
HFG1-12-SSM-S	Na_2O	13.3	12.645	0.677	5%
HFG1-12-SSM-S	P_2O_5	<0.229	0.049	0.180	
HFG1-12-SSM-S	SiO_2	47.4	47.255	0.184	0%
HFG1-12-SSM-S	SO_3	1.31	0.065	1.250	1921%
HFG1-12-SSM-S	ZnO	0.142	0.136	0.006	
HFG1-12-SSM-S	ZrO_2	11.5	12.052	-0.567	-5%
HFG1-12-SSM-S	**Sum Oxide**	**99.3**	**100**	**-0.727**	**-1%**
HFG1-13-SSM-S	Al_2O_3	8.24	8.557	-0.314	-4%
HFG1-13-SSM-S	B_2O_3	8.19	8.105	0.090	1%
HFG1-13-SSM-S	CaO	3.53	3.619	-0.086	-2%
HFG1-13-SSM-S	Cr_2O_3	<0.146	0.165	-0.019	
HFG1-13-SSM-S	F	2.85	4.568	-1.720	-38%
HFG1-13-SSM-S	Fe_2O_3	0.326	0.33	-0.004	
HFG1-13-SSM-S	K_2O	0.565	0.51	0.055	
HFG1-13-SSM-S	Li_2O	6.07	5.915	0.151	3%
HFG1-13-SSM-S	MnO	<0.156	0.165	-0.009	
HFG1-13-SSM-S	Na_2O	13.1	12.167	0.905	7%
HFG1-13-SSM-S	P_2O_5	<0.229	0.247	-0.018	
HFG1-13-SSM-S	SiO_2	50.1	48.981	1.130	2%
HFG1-13-SSM-S	SO_3	1.19	0.33	0.857	260%
HFG1-13-SSM-S	ZnO	1.79	1.75	0.039	2%
HFG1-13-SSM-S	ZrO_2	4.51	4.593	-0.081	-2%
HFG1-13-SSM-S	**Sum Oxide**	**101**	**100.002**	**0.975**	**1%**
HFG1-14-SSM-S	Al_2O_3	2.51	2.526	-0.013	-1%
HFG1-14-SSM-S	B_2O_3	4.6	4.945	-0.341	-7%
HFG1-14-SSM-S	CaO	5.86	5.743	0.116	2%
HFG1-14-SSM-S	Cr_2O_3	<0.146	0.056	0.090	
HFG1-14-SSM-S	F	3.13	4.479	-1.350	-30%
HFG1-14-SSM-S	Fe_2O_3	<0.143	0.113	0.030	
HFG1-14-SSM-S	K_2O	0.127	0.118	0.009	
HFG1-14-SSM-S	Li_2O	1.59	1.504	0.089	6%
HFG1-14-SSM-S	MnO	<0.129	0.056	0.073	
HFG1-14-SSM-S	Na_2O	21.6	22.035	-0.433	-2%
HFG1-14-SSM-S	P_2O_5	<0.229	0.085	0.144	
HFG1-14-SSM-S	SiO_2	45.9	48.453	-2.510	-5%
HFG1-14-SSM-S	SO_3	1.67	0.113	1.550	1375%
HFG1-14-SSM-S	ZnO	1.33	1.367	-0.038	-3%
HFG1-14-SSM-S	ZrO_2	7.69	8.409	-0.716	-9%
HFG1-14-SSM-S	**Sum Oxide**	**96.7**	**100.002**	**-3.290**	**-3%**
HFG1-15-SSM-S	Al_2O_3	5.04	5.051	-0.011	0%
HFG1-15-SSM-S	B_2O_3	8.3	8.532	-0.233	-3%
HFG1-15-SSM-S	CaO	4.61	4.619	-0.005	0%
HFG1-15-SSM-S	Cr_2O_3	0.147	0.177	-0.030	
HFG1-15-SSM-S	F	1.45	2.125	-0.675	-32%
HFG1-15-SSM-S	Fe_2O_3	0.371	0.335	0.036	
HFG1-15-SSM-S	K_2O	1.27	1.44	-0.169	-12%
HFG1-15-SSM-S	Li_2O	4.18	4.016	0.161	4%

Table A-4. Comparison of Measured and Targeted Compositions (continued)

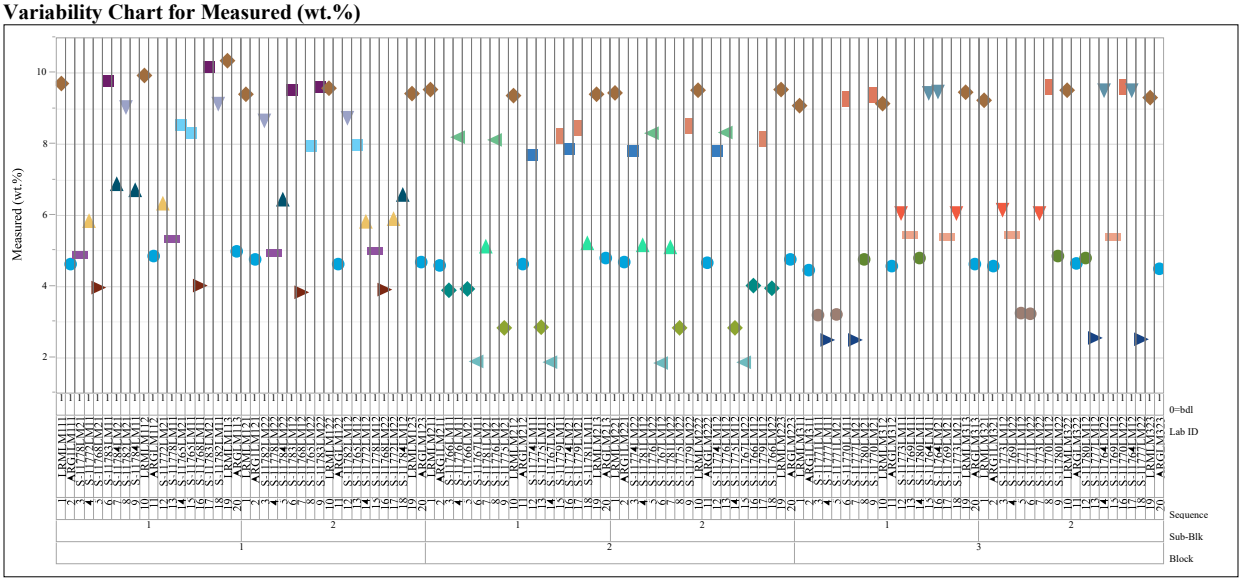
Glass ID	Oxide	Measured (wt.%)	Targeted (wt.%)	Difference of Measured versus Targeted (wt.%)	% Difference of Measured versus Targeted
HFG1-15-SSM-S	MnO	0.176	0.177	-0.001	
HFG1-15-SSM-S	Na_2O	15.7	15.702	0.002	0%
HFG1-15-SSM-S	P_2O_5	<0.229	0.266	-0.037	
HFG1-15-SSM-S	SiO_2	50	50.11	-0.104	0%
HFG1-15-SSM-S	SO_3	1.85	0.335	1.510	451%
HFG1-15-SSM-S	ZnO	0.545	0.551	-0.006	
HFG1-15-SSM-S	ZrO_2	6.12	6.523	-0.407	-6%
HFG1-15-SSM-S	**Sum Oxide**	**100**	**99.959**	**0.032**	**0%**
HFG1-16-SSM-S	Al_2O_3	8.34	8.682	-0.345	-4%
HFG1-16-SSM-S	B_2O_3	3.9	4.257	-0.361	-8%
HFG1-16-SSM-S	CaO	5.76	5.811	-0.050	-1%
HFG1-16-SSM-S	Cr_2O_3	<0.146	0.139	0.007	
HFG1-16-SSM-S	F	1.78	2.189	-0.407	-19%
HFG1-16-SSM-S	Fe_2O_3	0.29	0.278	0.012	
HFG1-16-SSM-S	K_2O	1.14	1.31	-0.171	-13%
HFG1-16-SSM-S	Li_2O	5.83	5.842	-0.013	0%
HFG1-16-SSM-S	MnO	0.138	0.139	-0.001	
HFG1-16-SSM-S	Na_2O	19.7	20.316	-0.635	-3%
HFG1-16-SSM-S	P_2O_5	<0.229	0.209	0.020	
HFG1-16-SSM-S	SiO_2	37.2	37.396	-0.226	-1%
HFG1-16-SSM-S	SO_3	1.89	0.278	1.610	579%
HFG1-16-SSM-S	ZnO	<0.124	0.041	0.084	
HFG1-16-SSM-S	ZrO_2	11.6	13.114	-1.510	-12%
HFG1-16-SSM-S	**Sum Oxide**	**98**	**100.001**	**-1.980**	**-2%**
HFG1-17-SSM-S	Al_2O_3	4.8	4.933	-0.129	-3%
HFG1-17-SSM-S	B_2O_3	3.89	4.044	-0.156	-4%
HFG1-17-SSM-S	CaO	3.85	3.772	0.083	2%
HFG1-17-SSM-S	Cr_2O_3	<0.146	0.076	0.070	
HFG1-17-SSM-S	F	1.98	2.547	-0.572	-22%
HFG1-17-SSM-S	Fe_2O_3	0.177	0.152	0.025	
HFG1-17-SSM-S	K_2O	0.19	0.197	-0.007	
HFG1-17-SSM-S	Li_2O	5.57	5.394	0.171	3%
HFG1-17-SSM-S	MnO	<0.129	0.076	0.053	
HFG1-17-SSM-S	Na_2O	17.7	17.748	-0.022	0%
HFG1-17-SSM-S	P_2O_5	<0.229	0.114	0.115	
HFG1-17-SSM-S	SiO_2	44.8	44.712	0.106	0%
HFG1-17-SSM-S	SO_3	1.45	0.152	1.300	855%
HFG1-17-SSM-S	ZnO	2.76	2.795	-0.032	-1%
HFG1-17-SSM-S	ZrO_2	12.5	13.288	-0.803	-6%
HFG1-17-SSM-S	**Sum Oxide**	**100**	**100**	**0.203**	**0%**
HFG1-18-SSM-S	Al_2O_3	5.15	5.277	-0.128	-2%
HFG1-18-SSM-S	B_2O_3	11.8	11.8	0.049	0%
HFG1-18-SSM-S	CaO	0.477	0.488	-0.011	
HFG1-18-SSM-S	Cr_2O_3	<0.146	0.062	0.084	
HFG1-18-SSM-S	F	2.24	3.882	-1.640	-42%
HFG1-18-SSM-S	Fe_2O_3	0.161	0.124	0.037	
HFG1-18-SSM-S	K_2O	0.389	0.389	0.000	

Table A-4. Comparison of Measured and Targeted Compositions (continued)

Glass ID	Oxide	Measured (wt.%)	Targeted (wt.%)	Difference of Measured versus Targeted (wt.%)	% Difference of Measured versus Targeted
HFG1-18-SSM-S	Li_2O	5.06	4.91	0.149	3%
HFG1-18-SSM-S	MnO	<0.129	0.062	0.067	
HFG1-18-SSM-S	Na_2O	13.6	12.936	0.679	5%
HFG1-18-SSM-S	P_2O_5	<0.229	0.093	0.136	
HFG1-18-SSM-S	SiO_2	52.5	50.397	2.120	4%
HFG1-18-SSM-S	SO_3	1.02	0.124	0.895	722%
HFG1-18-SSM-S	ZnO	2.39	2.317	0.070	3%
HFG1-18-SSM-S	ZrO_2	6.99	7.138	-0.144	-2%
HFG1-18-SSM-S	**Sum Oxide**	**102**	**99.999**	**2.370**	**2%**
HFG1-19-SSM-S	Al_2O_3	8.9	8.812	0.092	1%
HFG1-19-SSM-S	B_2O_3	7.99	8.301	-0.316	-4%
HFG1-19-SSM-S	CaO	4.58	4.524	0.058	1%
HFG1-19-SSM-S	Cr_2O_3	<0.146	0.032	0.114	
HFG1-19-SSM-S	F	3.73	5.659	-1.930	-34%
HFG1-19-SSM-S	Fe_2O_3	<0.143	0.064	0.079	
HFG1-19-SSM-S	K_2O	1.05	1.147	-0.101	-9%
HFG1-19-SSM-S	Li_2O	1.28	1.305	-0.024	-2%
HFG1-19-SSM-S	MnO	<0.129	0.032	0.097	
HFG1-19-SSM-S	Na_2O	21.6	22.557	-0.922	-4%
HFG1-19-SSM-S	P_2O_5	<0.229	0.048	0.181	
HFG1-19-SSM-S	SiO_2	39.3	38.764	0.546	1%
HFG1-19-SSM-S	SO_3	1.52	0.064	1.460	2279%
HFG1-19-SSM-S	ZnO	3.1	3.063	0.040	1%
HFG1-19-SSM-S	ZrO_2	5.38	5.625	-0.249	-4%
HFG1-19-SSM-S	**Sum Oxide**	**99.1**	**99.997**	**-0.872**	**-1%**
HFG1-20-SSM-S	Al_2O_3	9.78	9.885	-0.107	-1%
HFG1-20-SSM-S	B_2O_3	4.22	4.54	-0.322	-7%
HFG1-20-SSM-S	CaO	2.09	2.087	0.005	0%
HFG1-20-SSM-S	Cr_2O_3	<0.146	0.118	0.028	
HFG1-20-SSM-S	F	2.14	2.717	-0.580	-21%
HFG1-20-SSM-S	Fe_2O_3	0.256	0.236	0.020	
HFG1-20-SSM-S	K_2O	<0.12	0.027	0.094	
HFG1-20-SSM-S	Li_2O	4.18	4.243	-0.066	-2%
HFG1-20-SSM-S	MnO	<0.131	0.118	0.013	
HFG1-20-SSM-S	Na_2O	22.6	23.821	-1.210	-5%
HFG1-20-SSM-S	P_2O_5	<0.229	0.177	0.052	
HFG1-20-SSM-S	SiO_2	41.1	40.989	0.139	0%
HFG1-20-SSM-S	SO_3	1.61	0.236	1.380	583%
HFG1-20-SSM-S	ZnO	3.87	3.868	0.000	0%
HFG1-20-SSM-S	ZrO_2	6.55	6.94	-0.392	-6%
HFG1-20-SSM-S	**Sum Oxide**	**99.1**	**100.002**	**-0.947**	**-1%**

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

Oxide=Al_2O_3
Variability Chart for Measured (wt.%)



Oxide=B_2O_3
Variability Chart for Measured (wt.%)

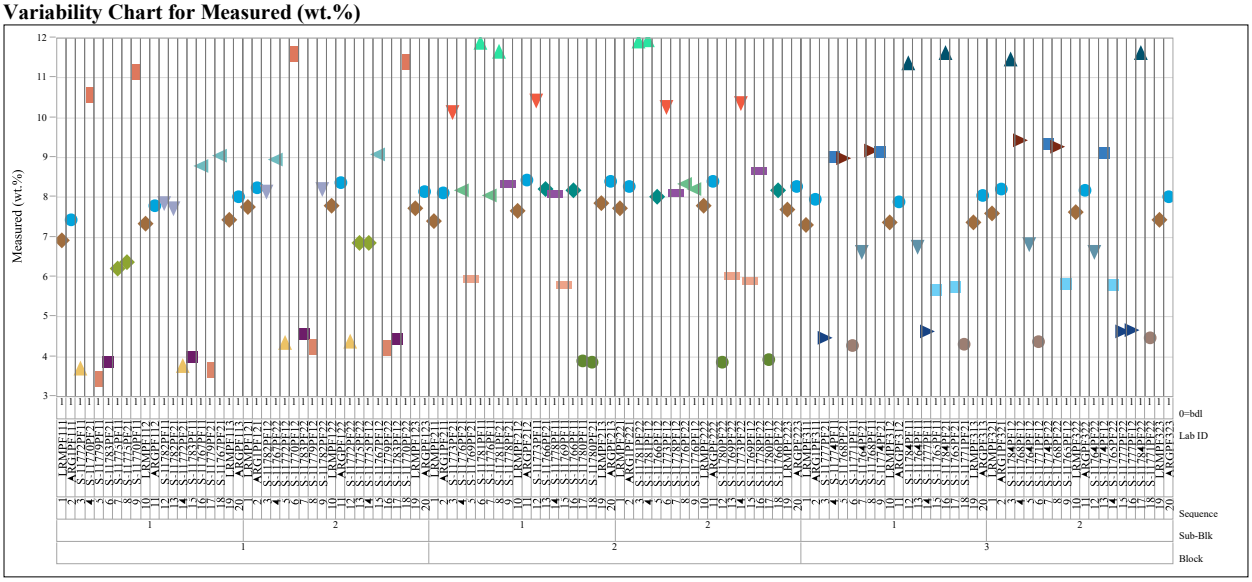
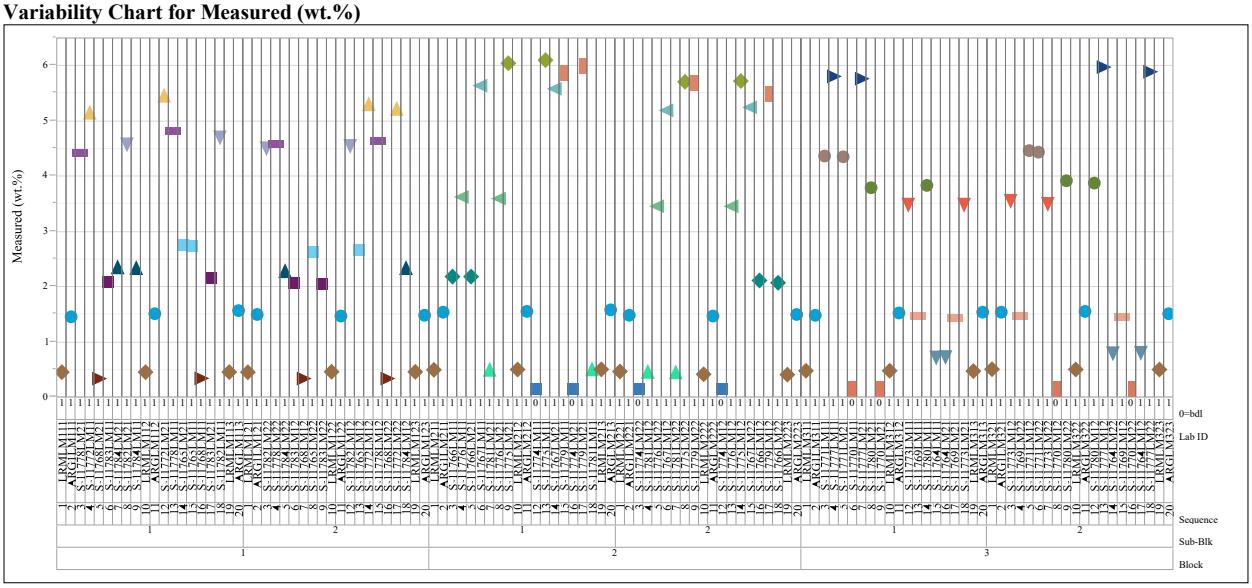


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Oxide=CaO
Variability Chart for Measured (wt.%)



Oxide=Cr_2O_3
Variability Chart for Measured (wt.%)

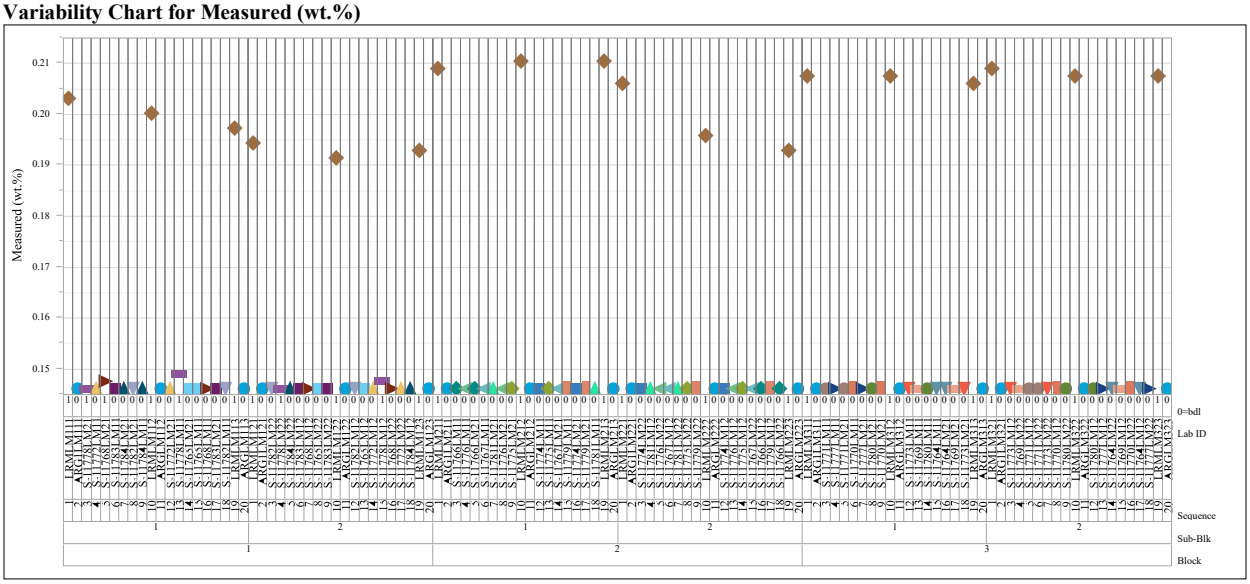
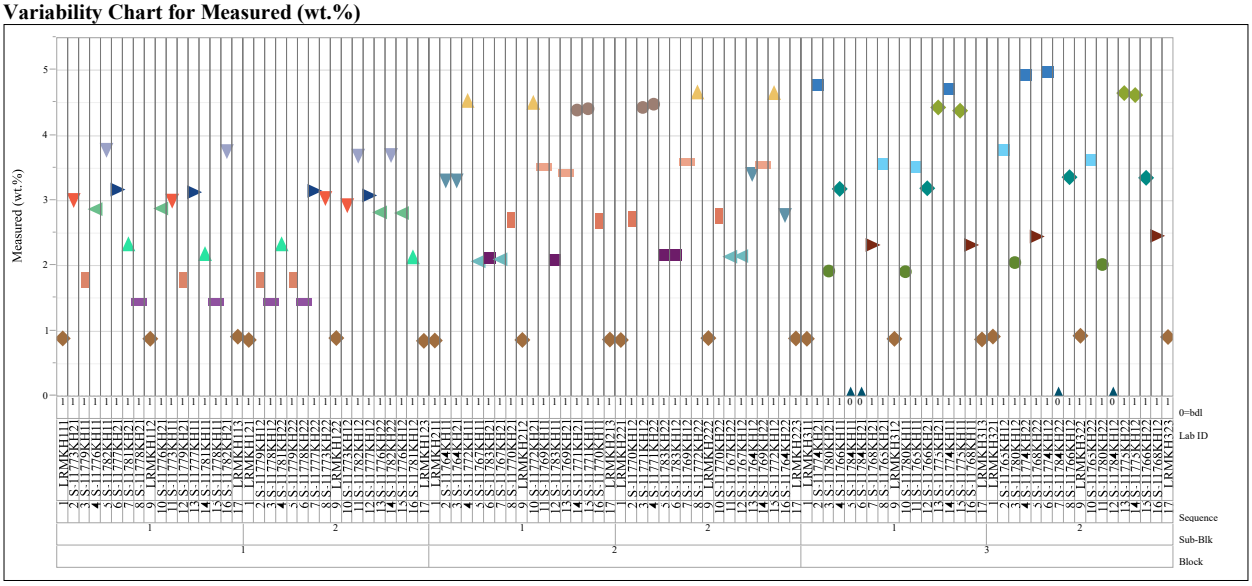


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Oxide=F
Variability Chart for Measured (wt.%)



Oxide=Fe_2O_3
Variability Chart for Measured (wt.%)

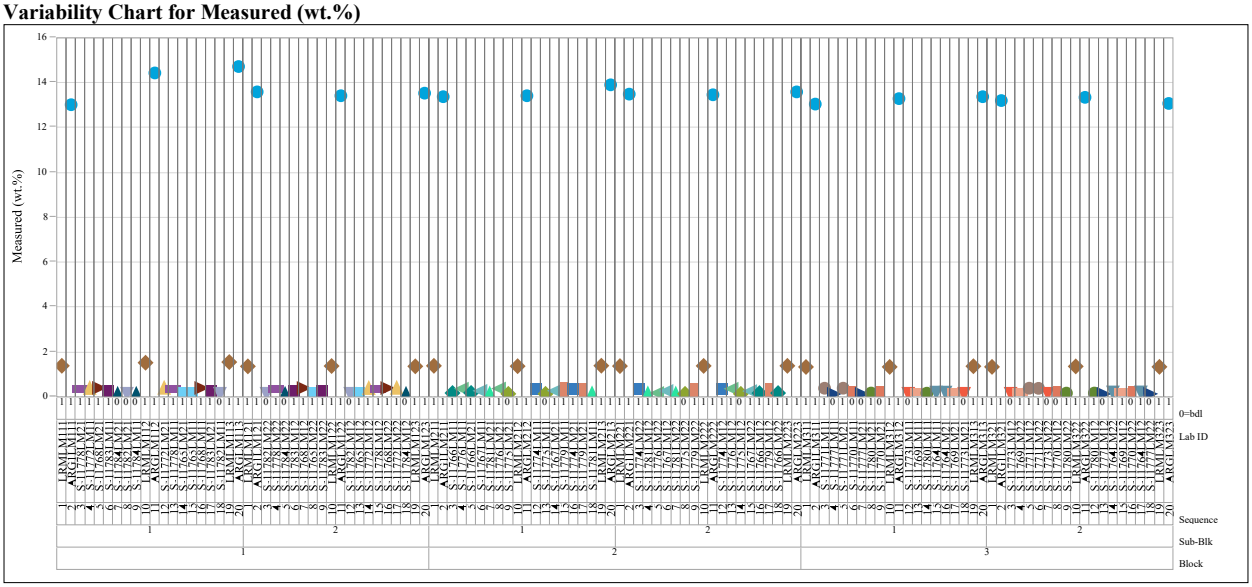
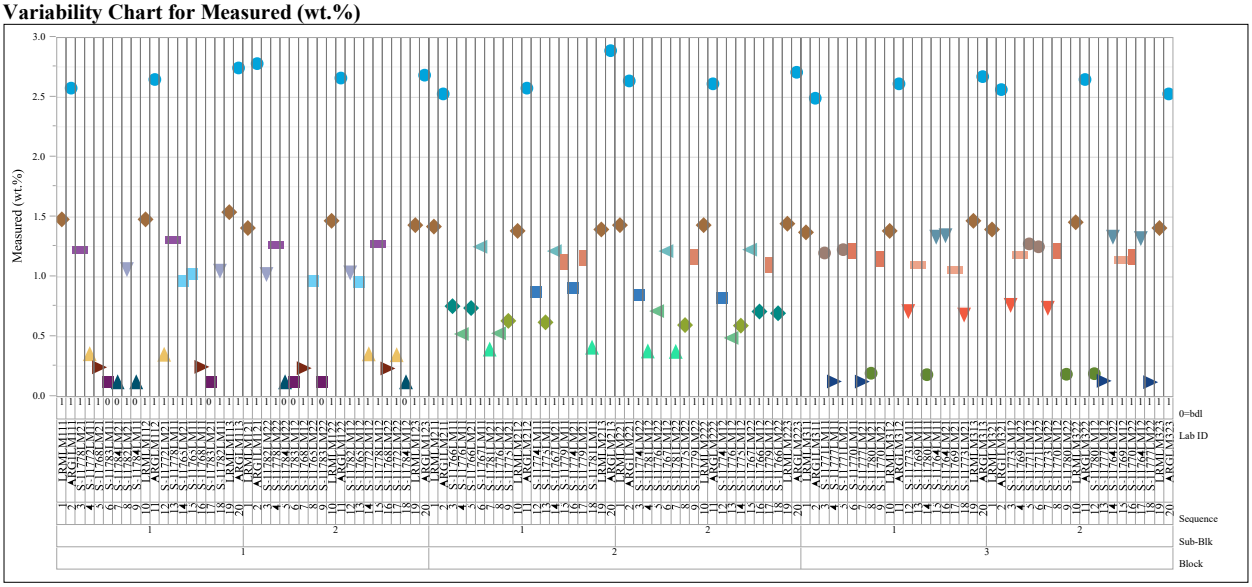


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Oxide=K_2O
Variability Chart for Measured (wt.%)



Oxide=Li_2O
Variability Chart for Measured (wt.%)

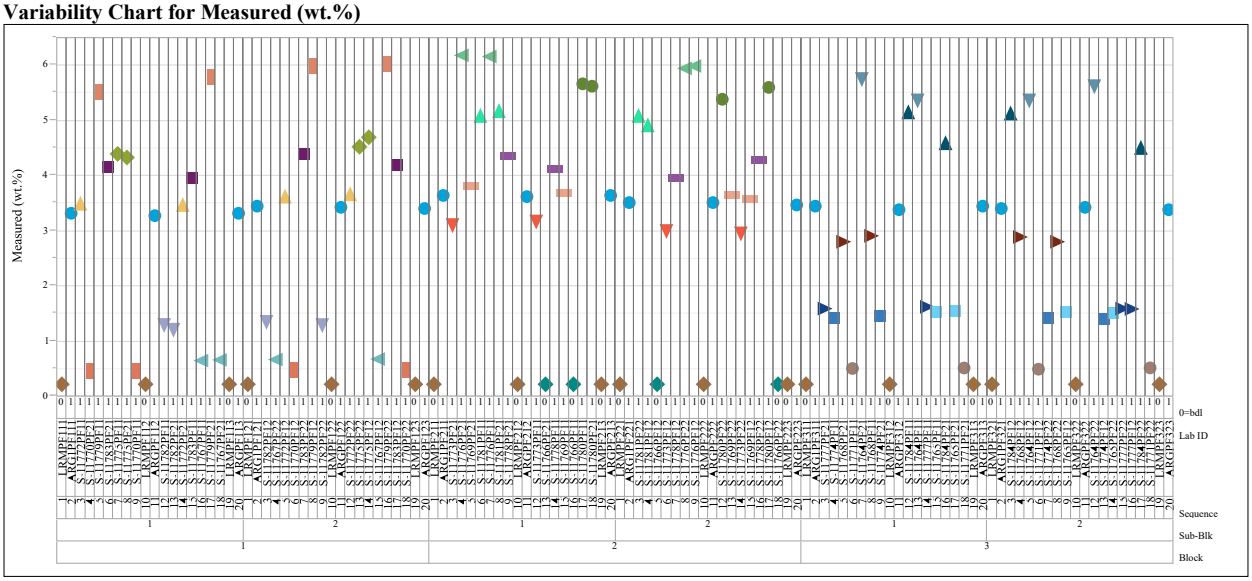
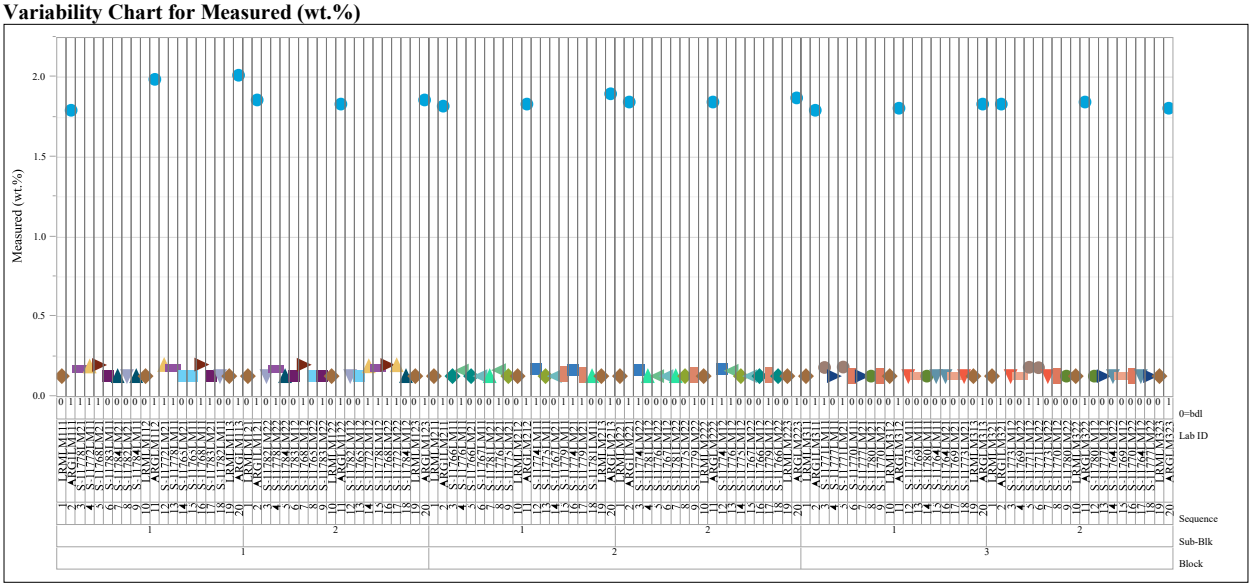


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Oxide=MnO
Variability Chart for Measured (wt.%)



Oxide=Na_2O
Variability Chart for Measured (wt.%)

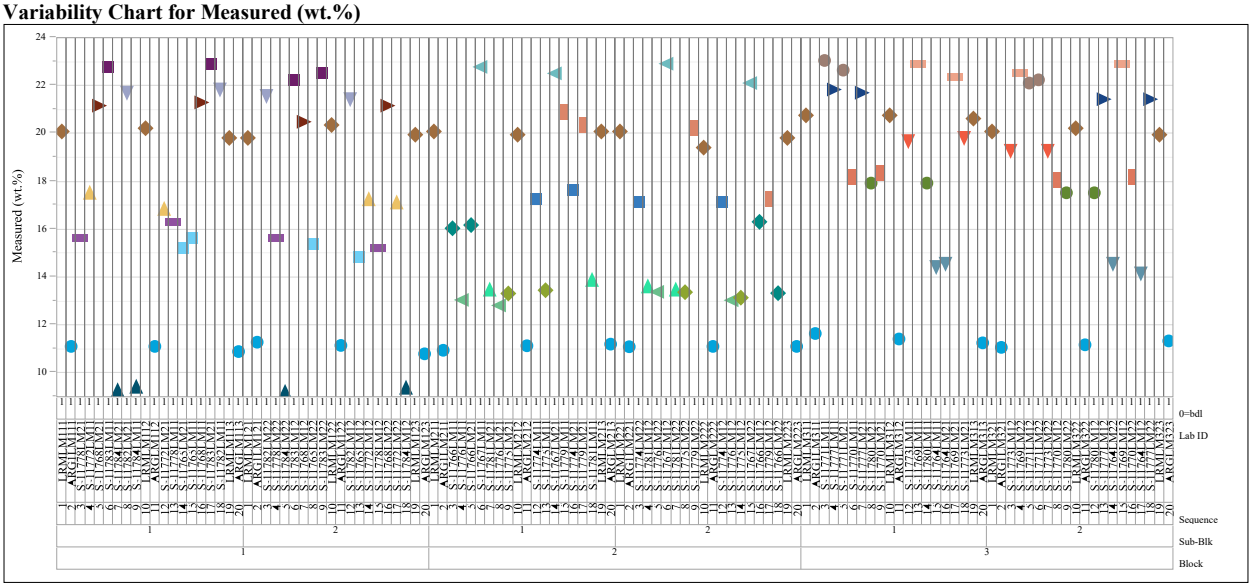
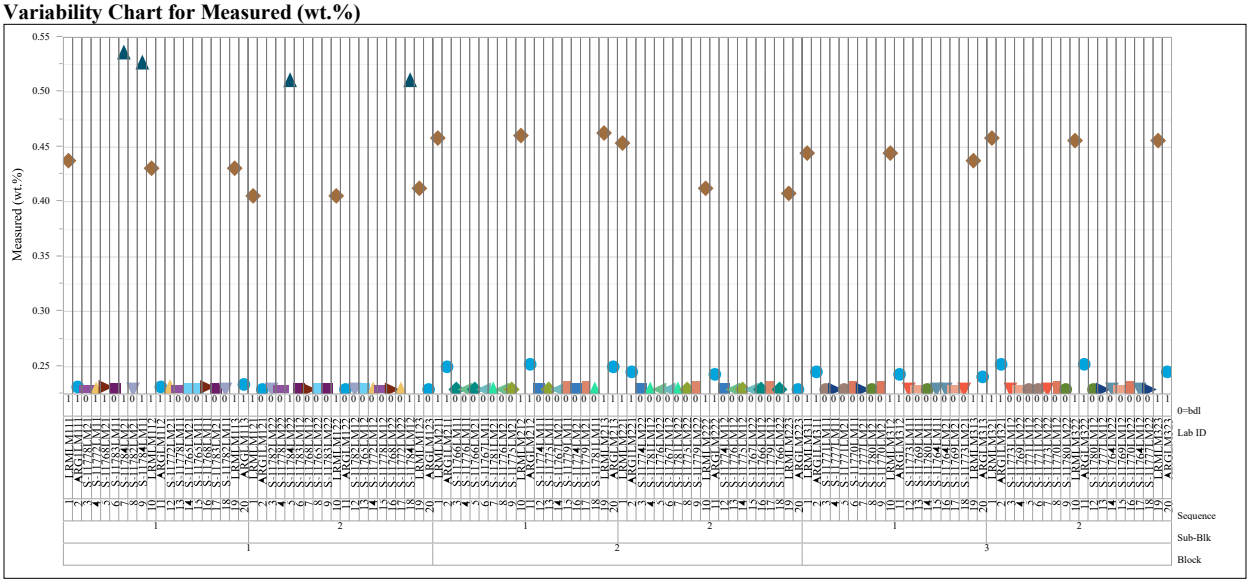


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Oxide=P_2O_5
Variability Chart for Measured (wt.%)



Oxide=SiO_2
Variability Chart for Measured (wt.%)

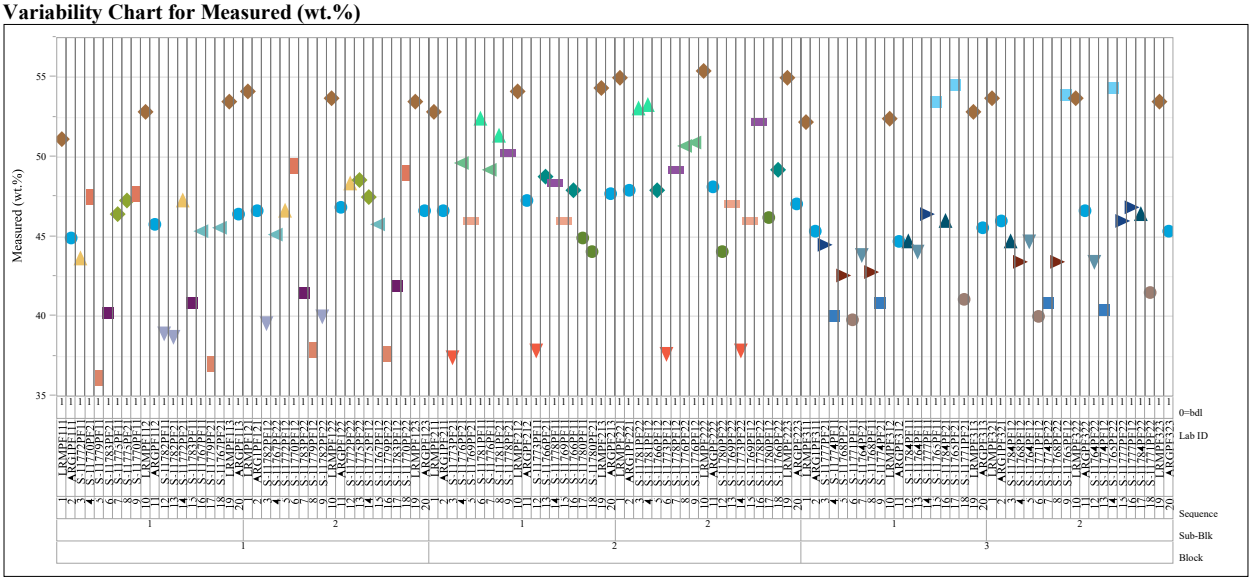
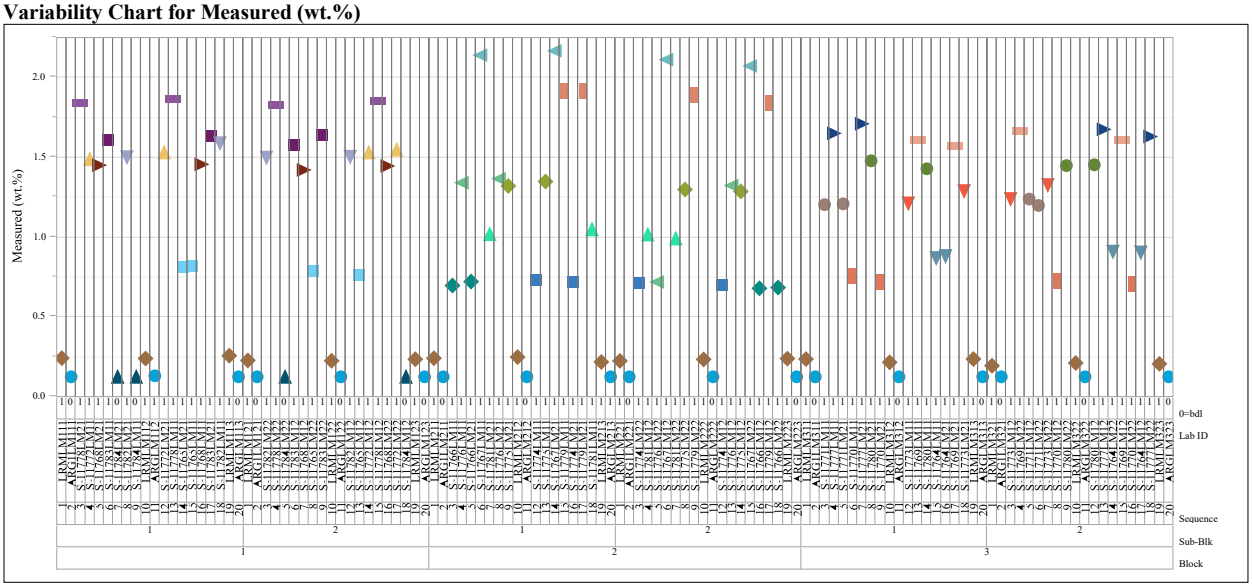


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Oxide=SO_3
Variability Chart for Measured (wt.%)



Oxide=ZnO
Variability Chart for Measured (wt.%)

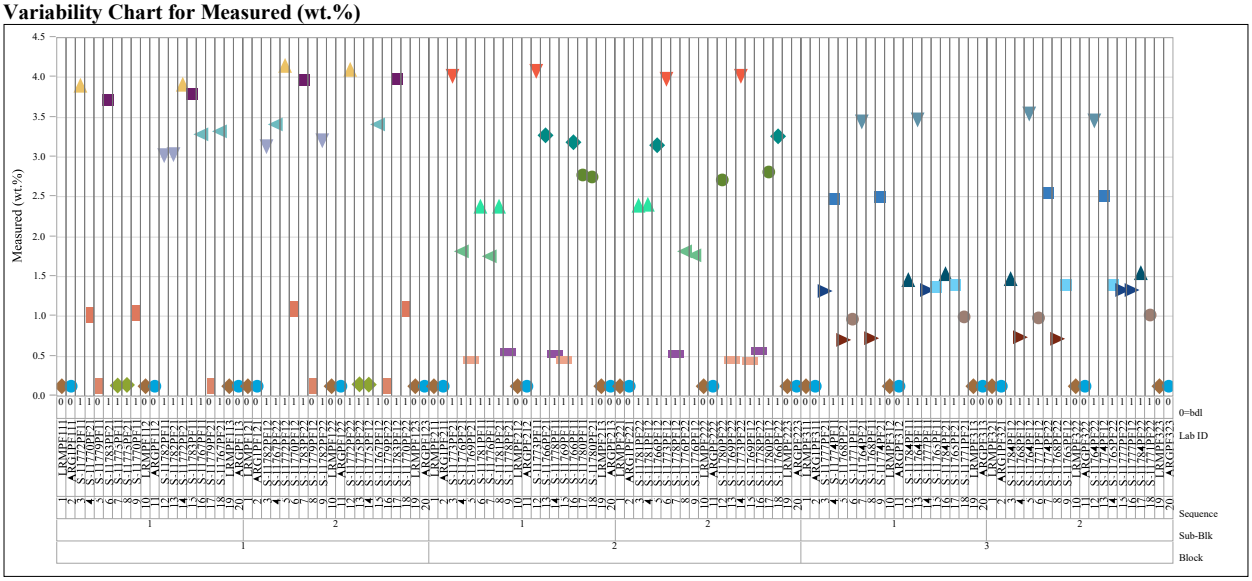


Exhibit A-1. Plots of Oxide Measurements in Analytical Sequence (continued)

Oxide=ZrO_2
Variability Chart for Measured (wt.%)

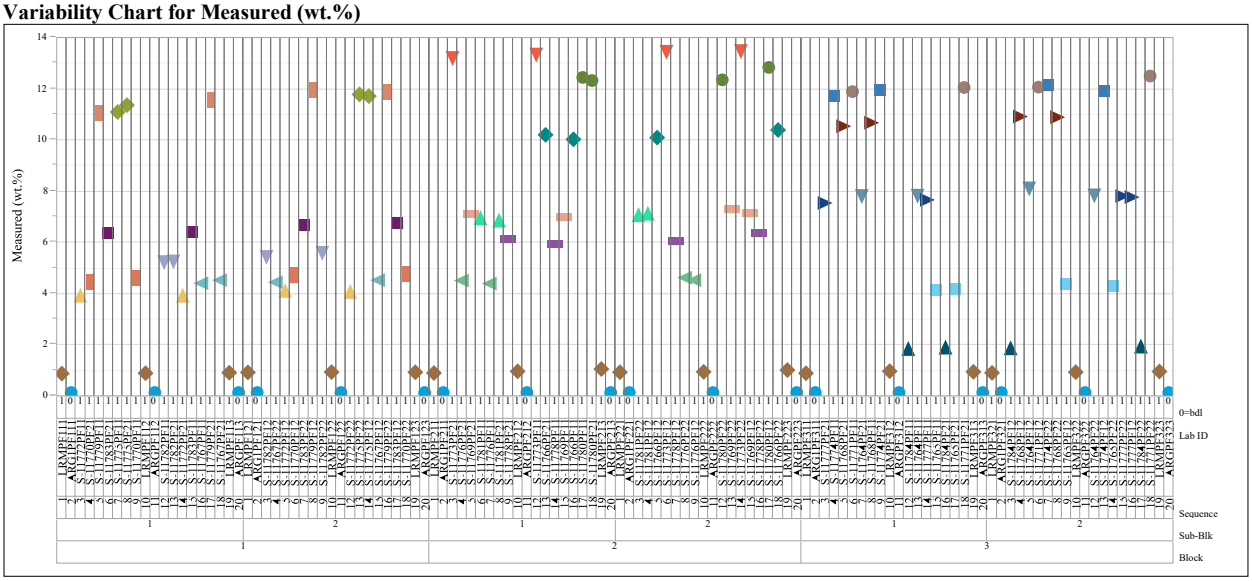
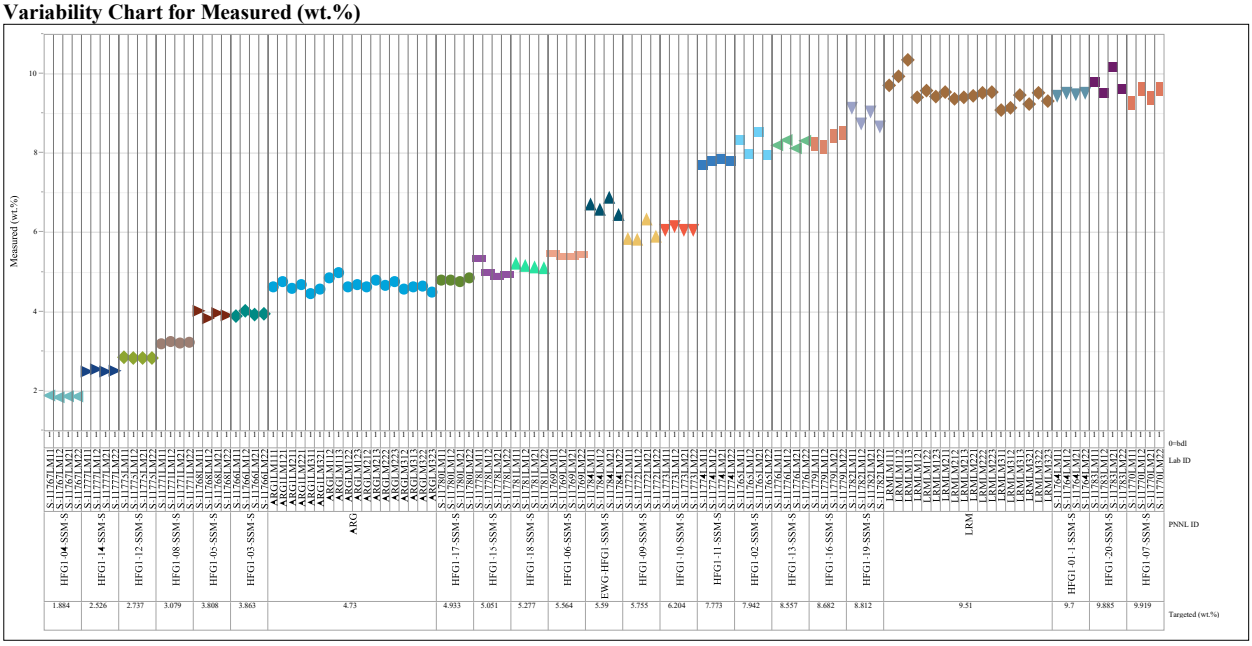


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier by Targeted Concentrations

Oxide=Al_2O_3
Variability Chart for Measured (wt.%)



Oxide=B_2O_3
Variability Chart for Measured (wt.%)

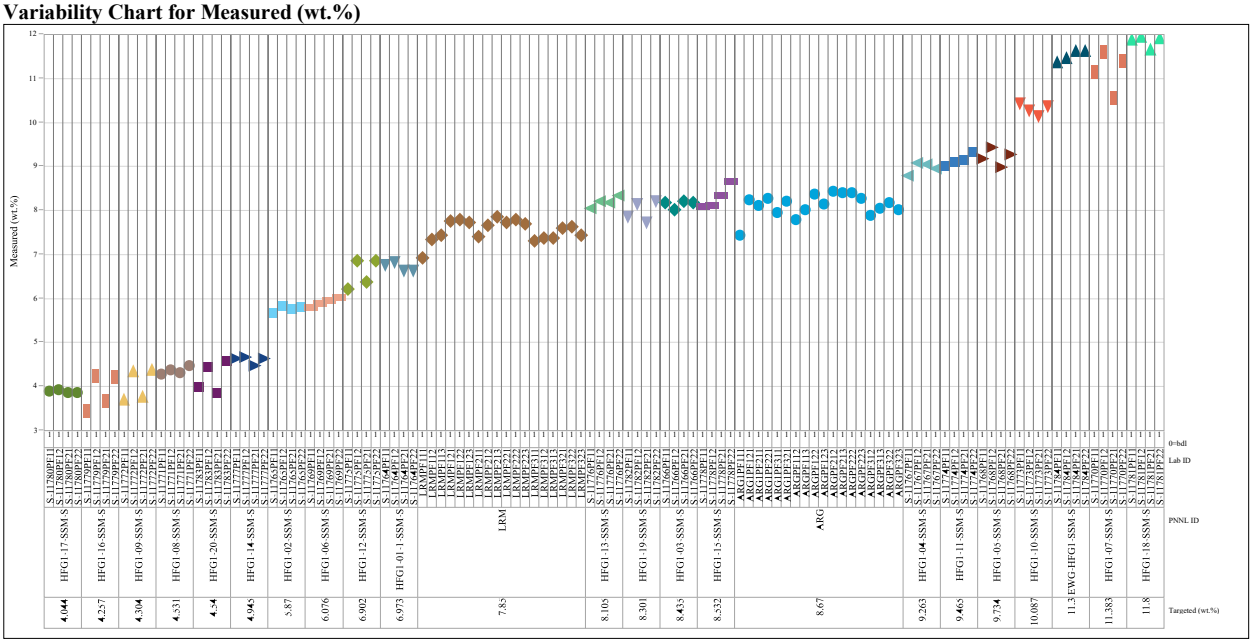
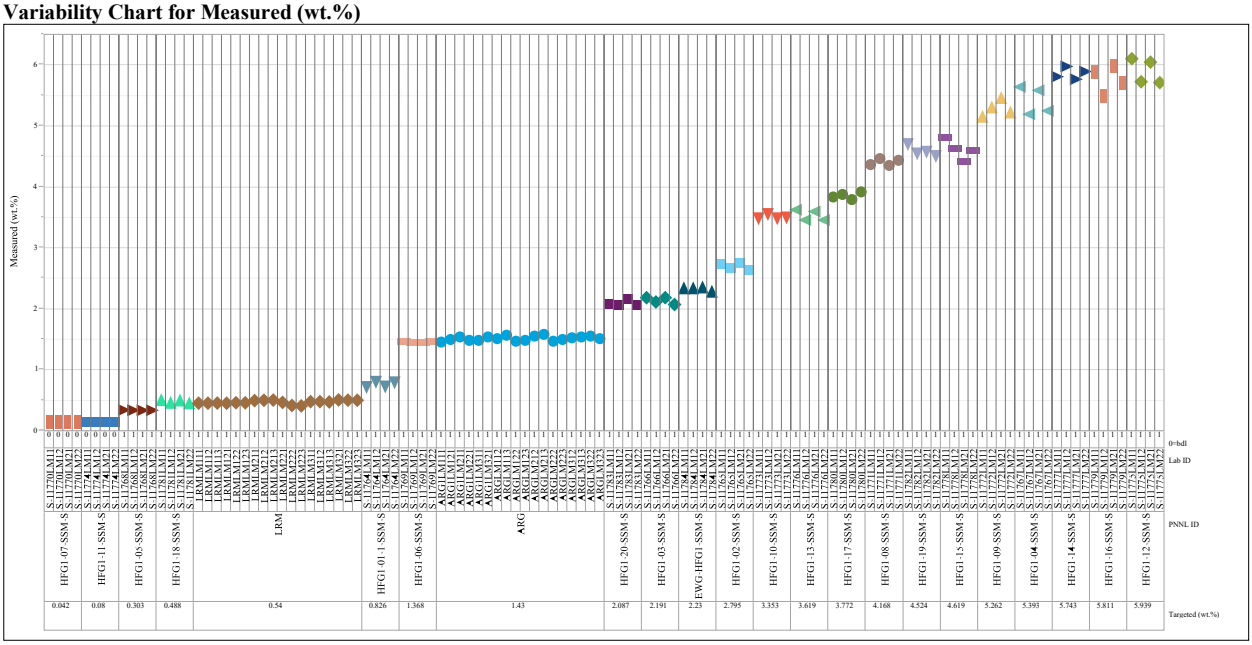


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier by Targeted Concentrations (continued)

Oxide=CaO
Variability Chart for Measured (wt.%)



Oxide=Cr_2O_3
Variability Chart for Measured (wt.%)

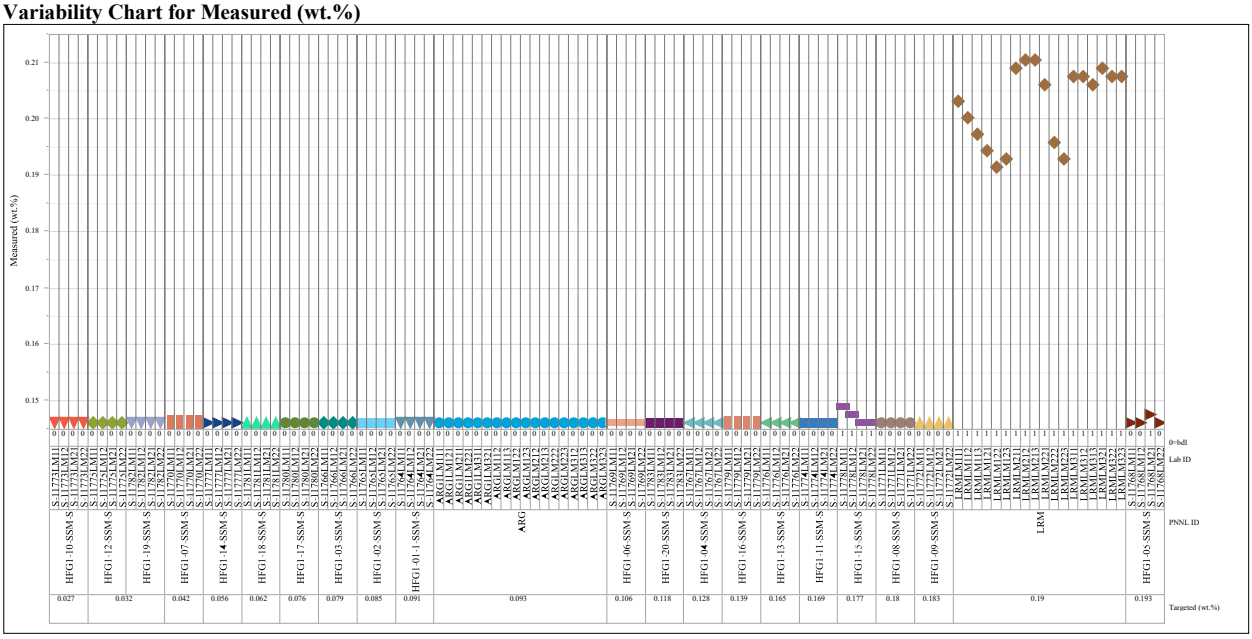
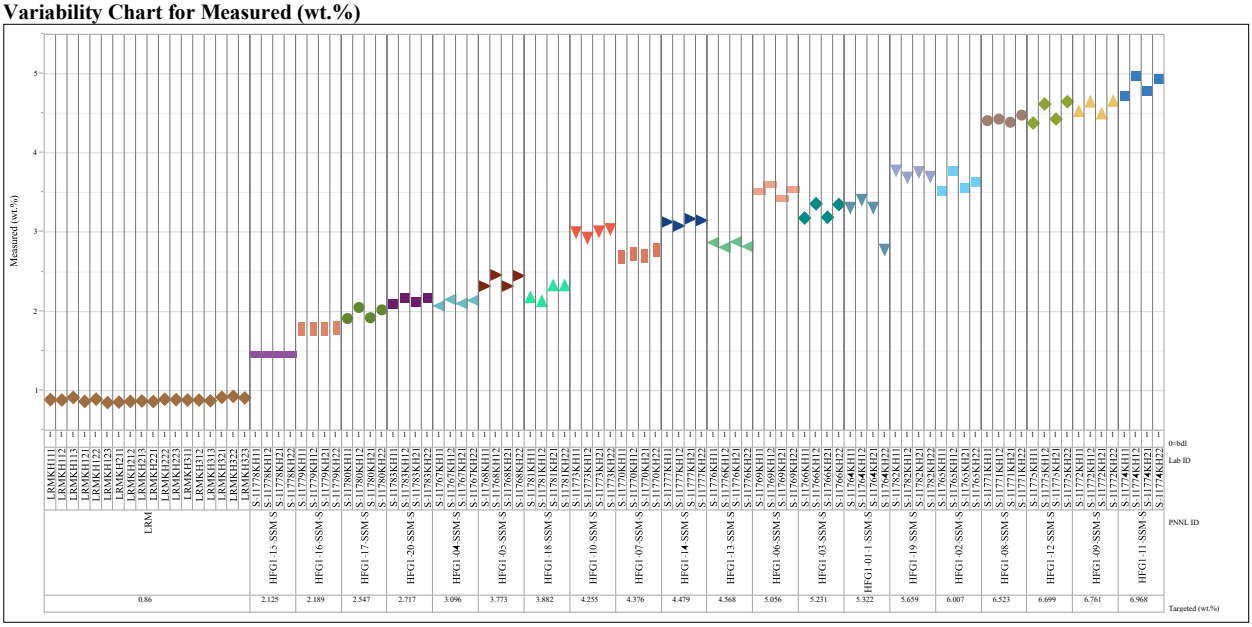


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier by Targeted Concentrations (continued)

Oxide=F
Variability Chart for Measured (wt.%)



Oxide=Fe_2O_3
Variability Chart for Measured (wt.%)

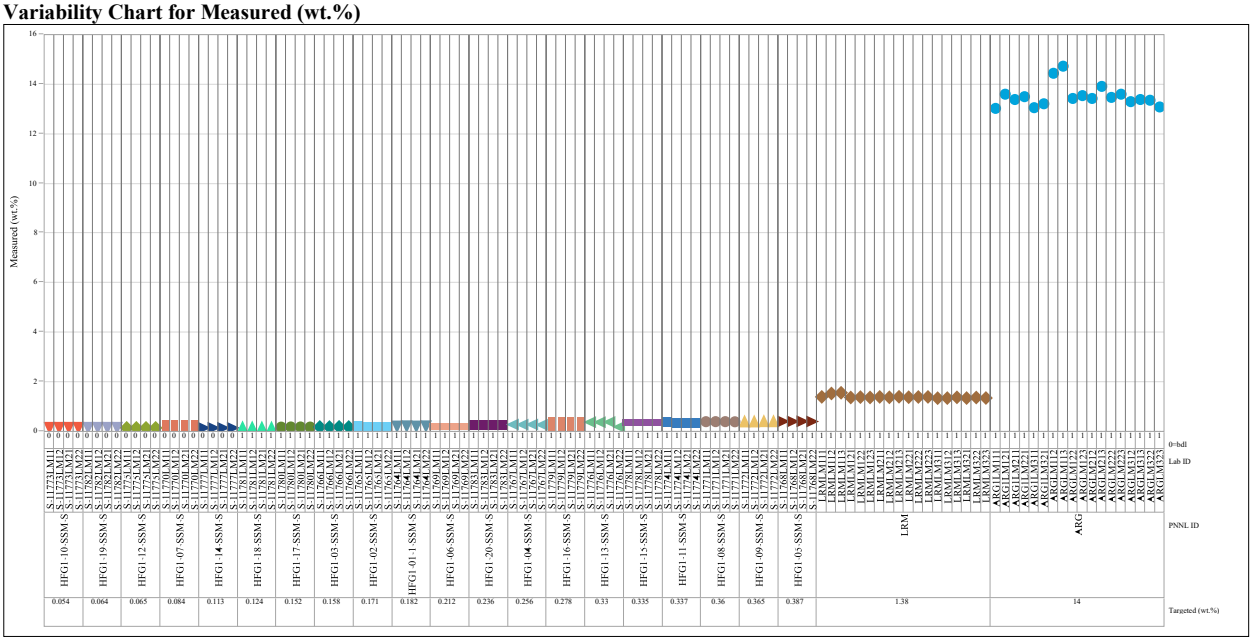
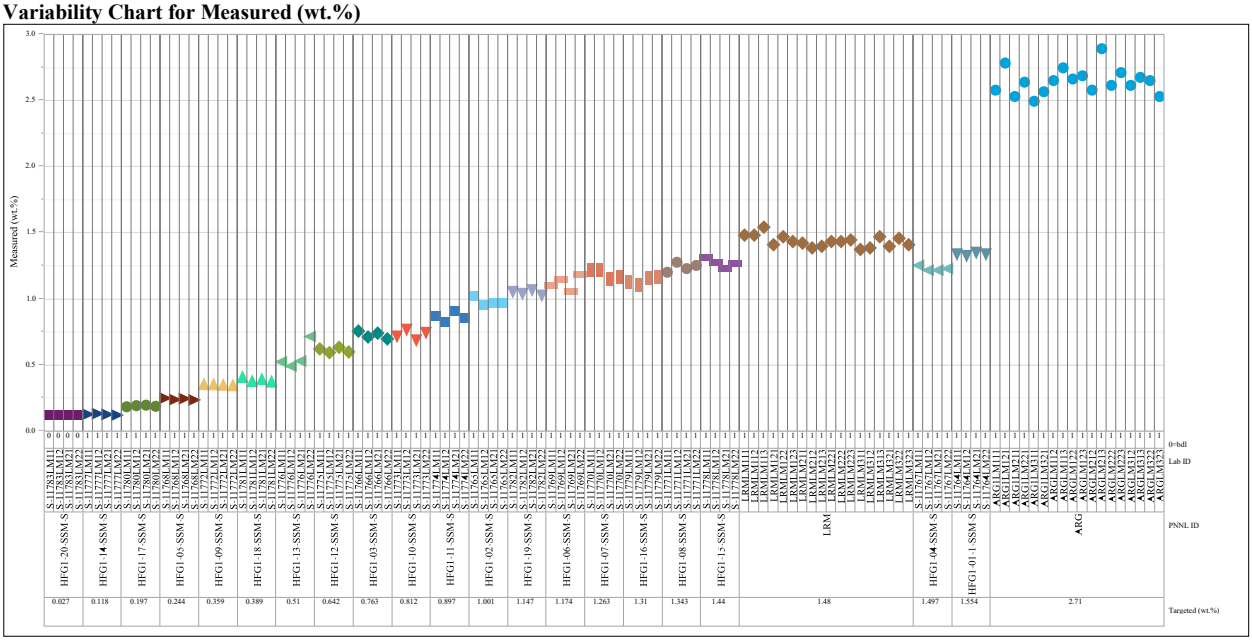


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier by Targeted Concentrations (continued)

Oxide=K_2O
Variability Chart for Measured (wt.%)



Oxide=Li_2O
Variability Chart for Measured (wt.%)

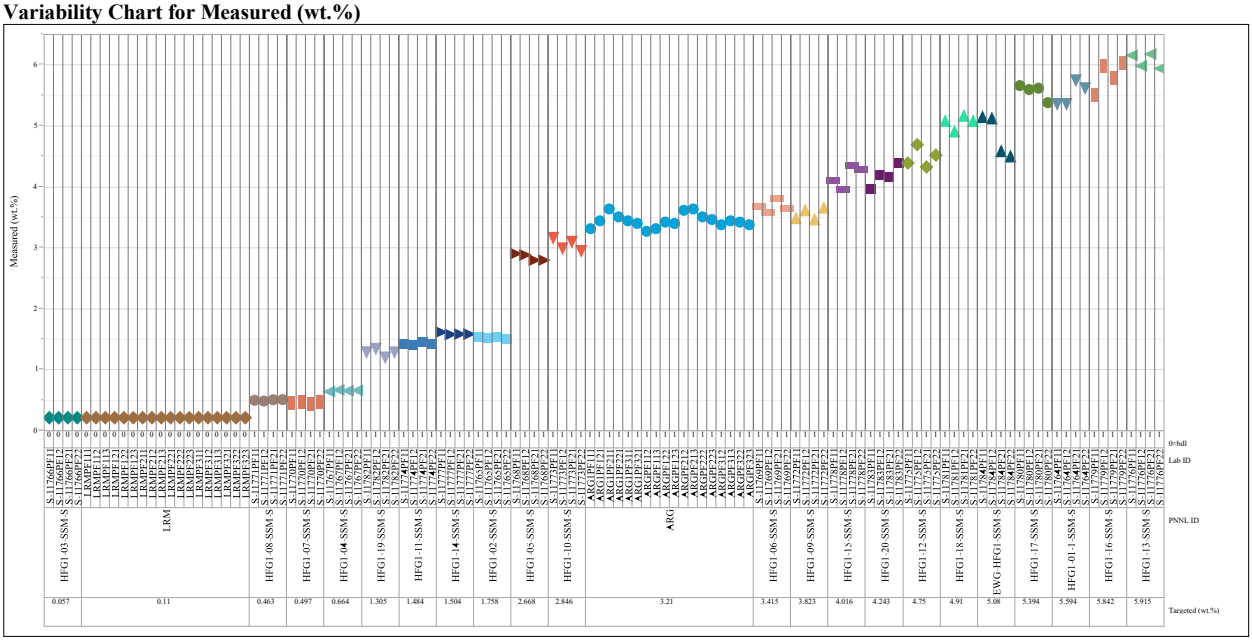
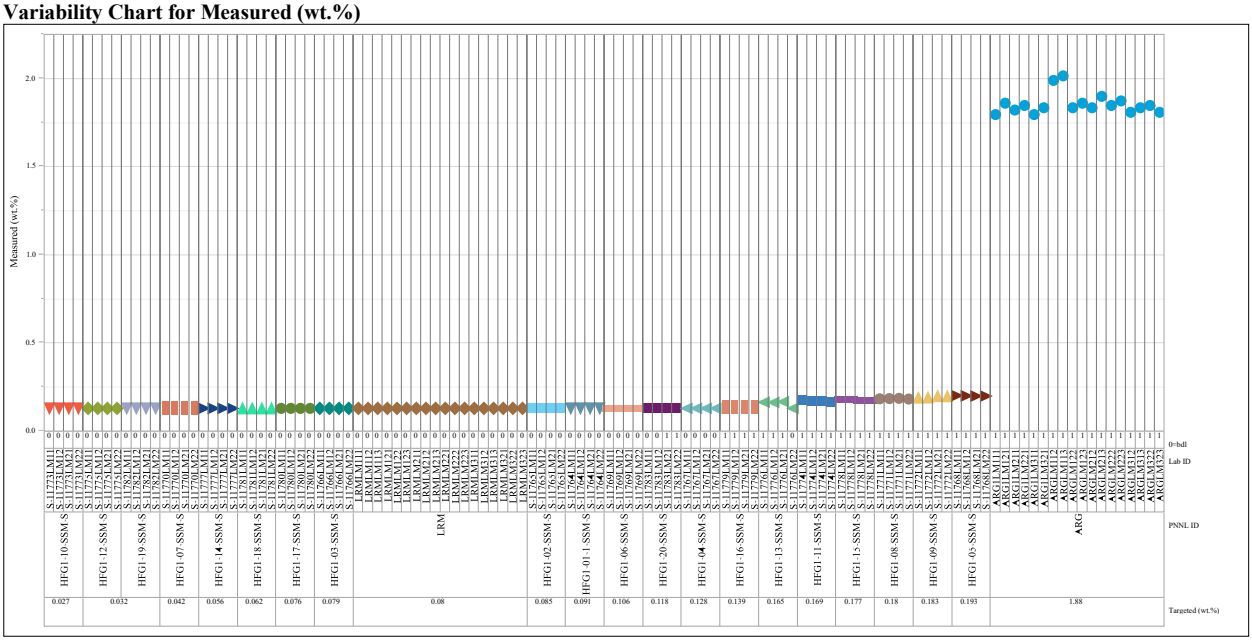


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier by Targeted Concentrations (continued)

Oxide=MnO
Variability Chart for Measured (wt.%)



Oxide=Na_2O
Variability Chart for Measured (wt.%)

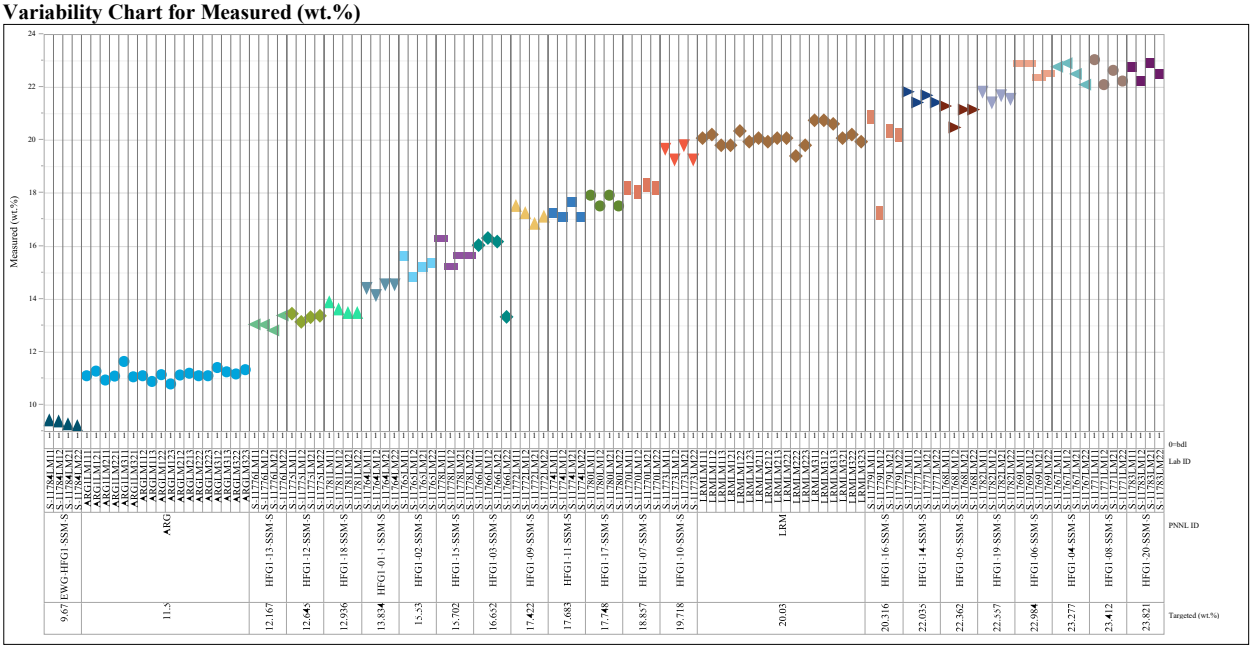
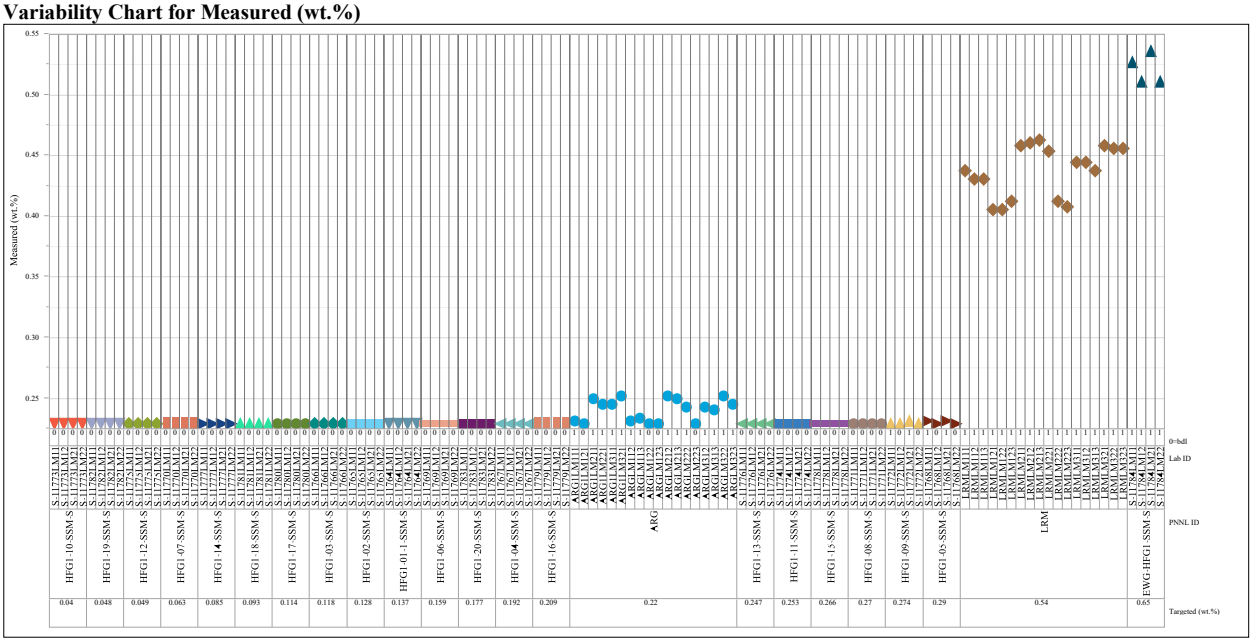


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier by Targeted Concentrations (continued)

Oxide=P_2O_5
Variability Chart for Measured (wt.%)



Oxide=SiO_2
Variability Chart for Measured (wt.%)

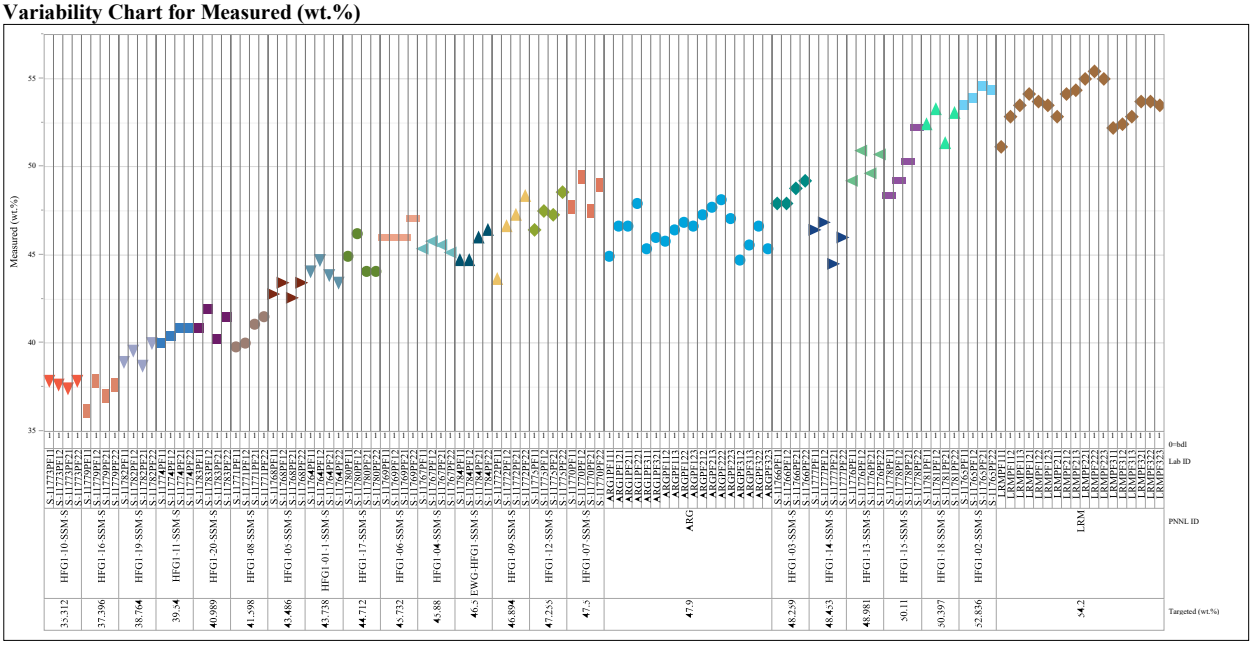
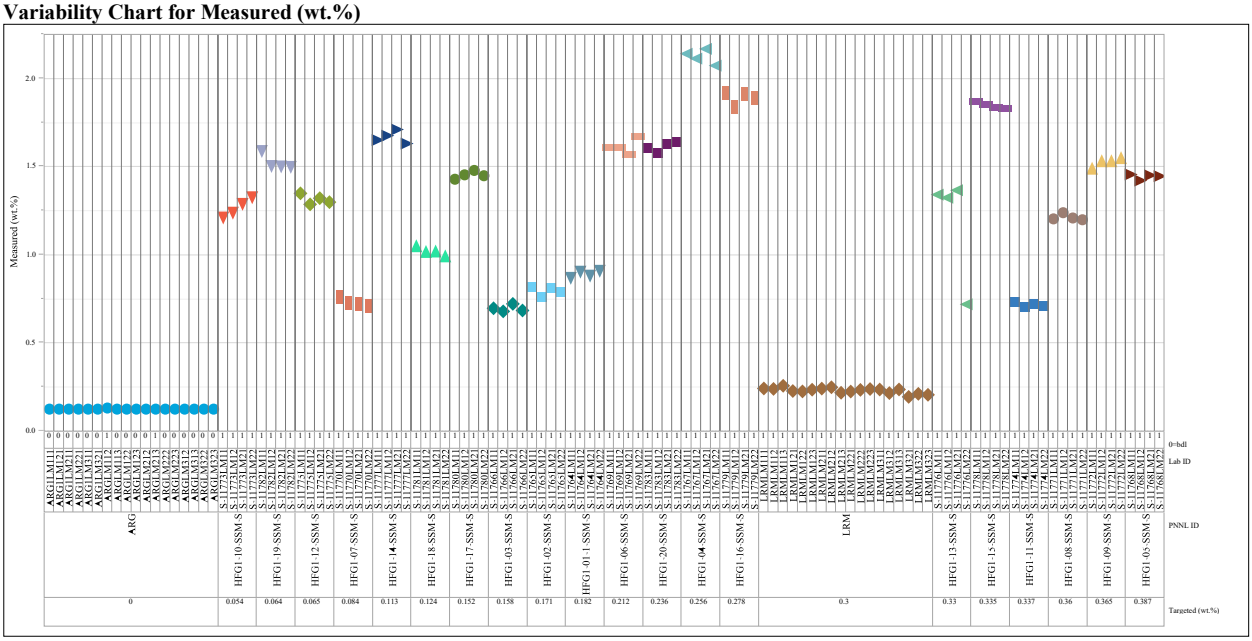


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier by Targeted Concentrations (continued)

Oxide=SO_3
Variability Chart for Measured (wt.%)



Oxide=ZnO
Variability Chart for Measured (wt.%)

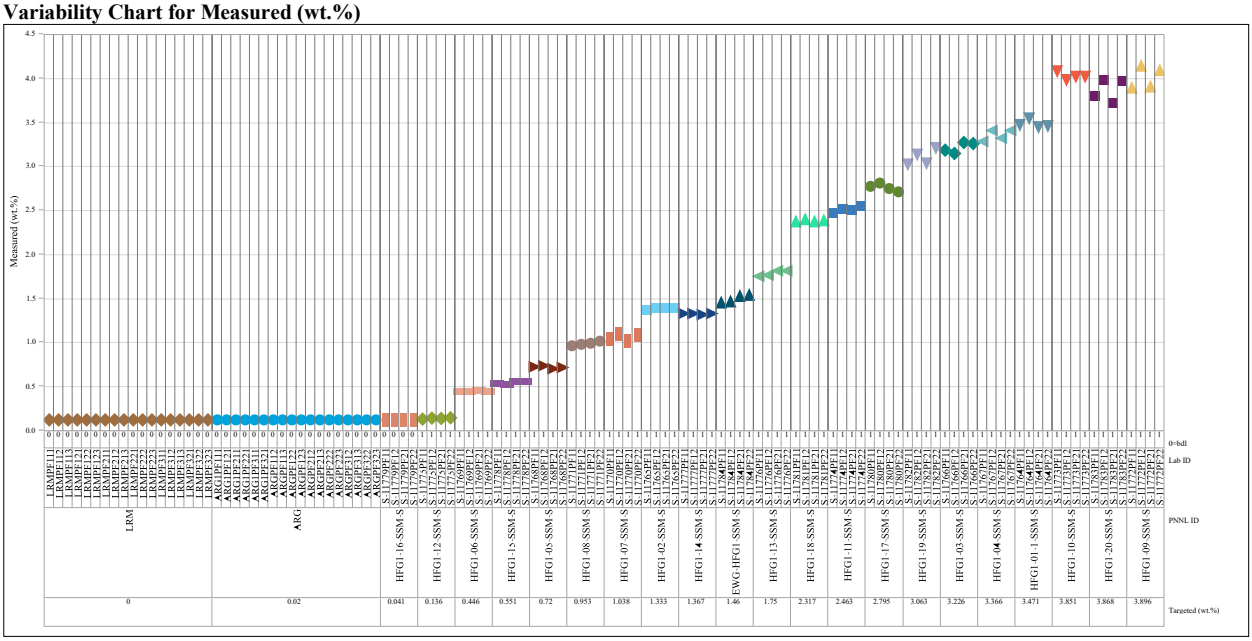


Exhibit A-2. Plots of Oxide Measurements by Glass Identifier by Targeted Concentrations (continued)

Oxide=ZrO_2
Variability Chart for Measured (wt.%)

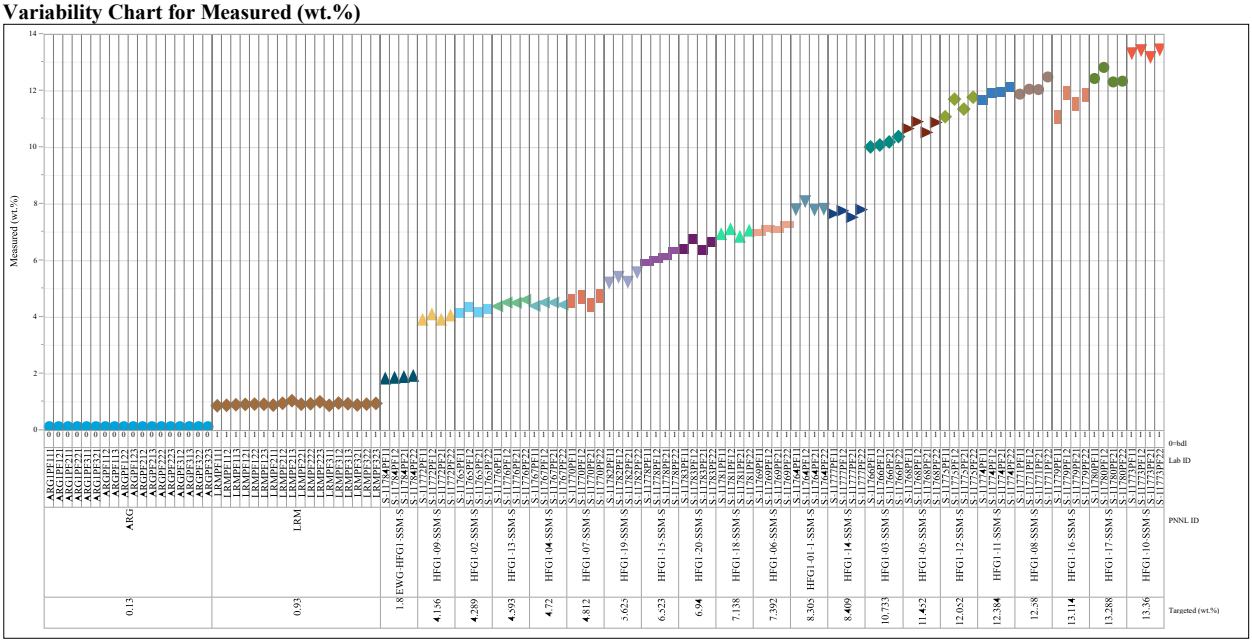
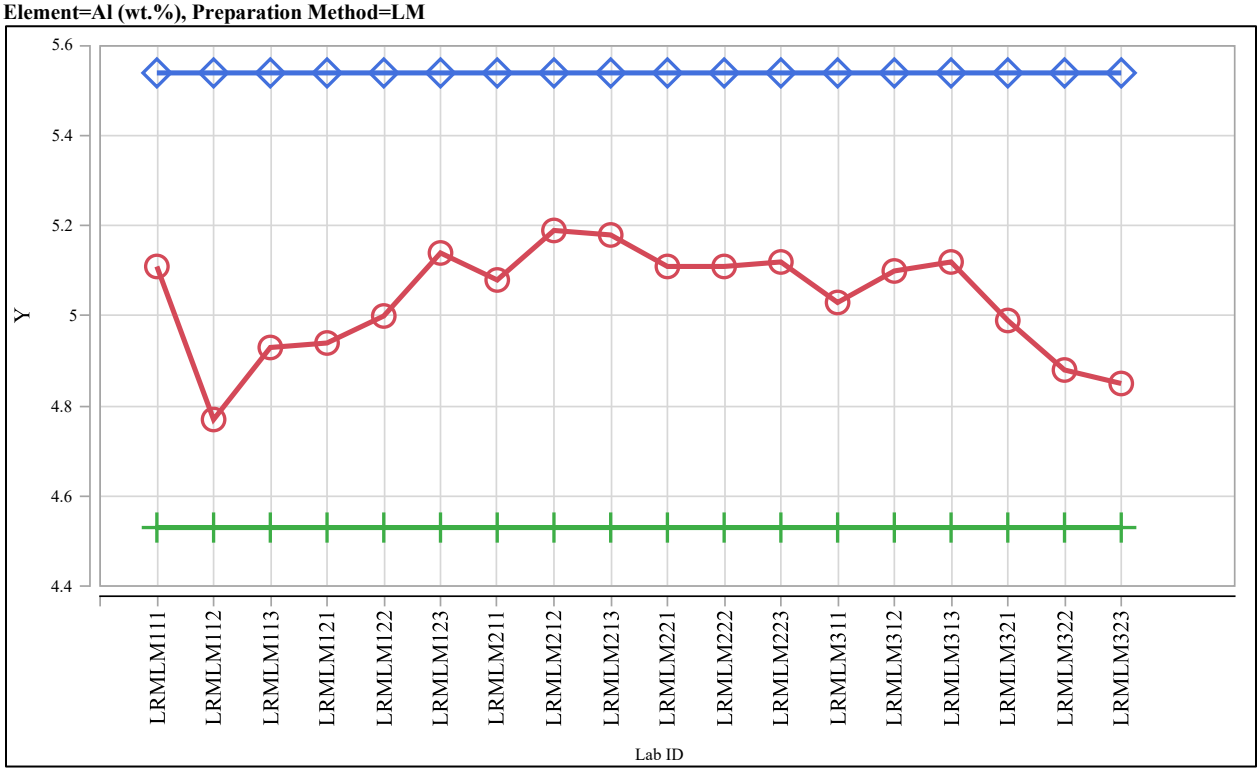
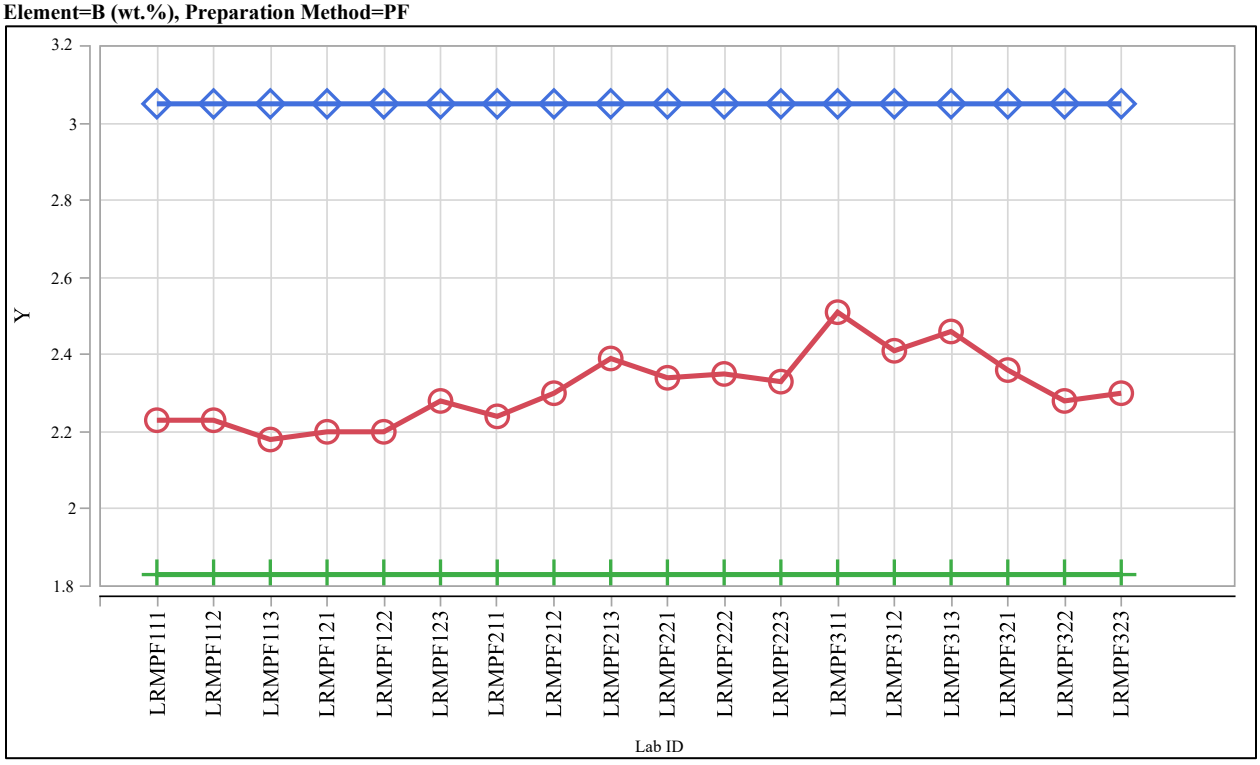


Exhibit A-3. Acceptability Evaluation for Measurements of the LRM Glass

Element=Al (wt.%), Preparation Method=LM



Element=B (wt.%), Preparation Method=PF



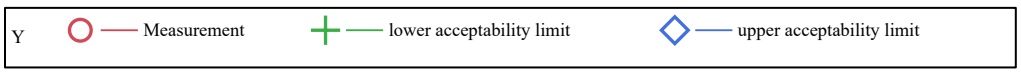
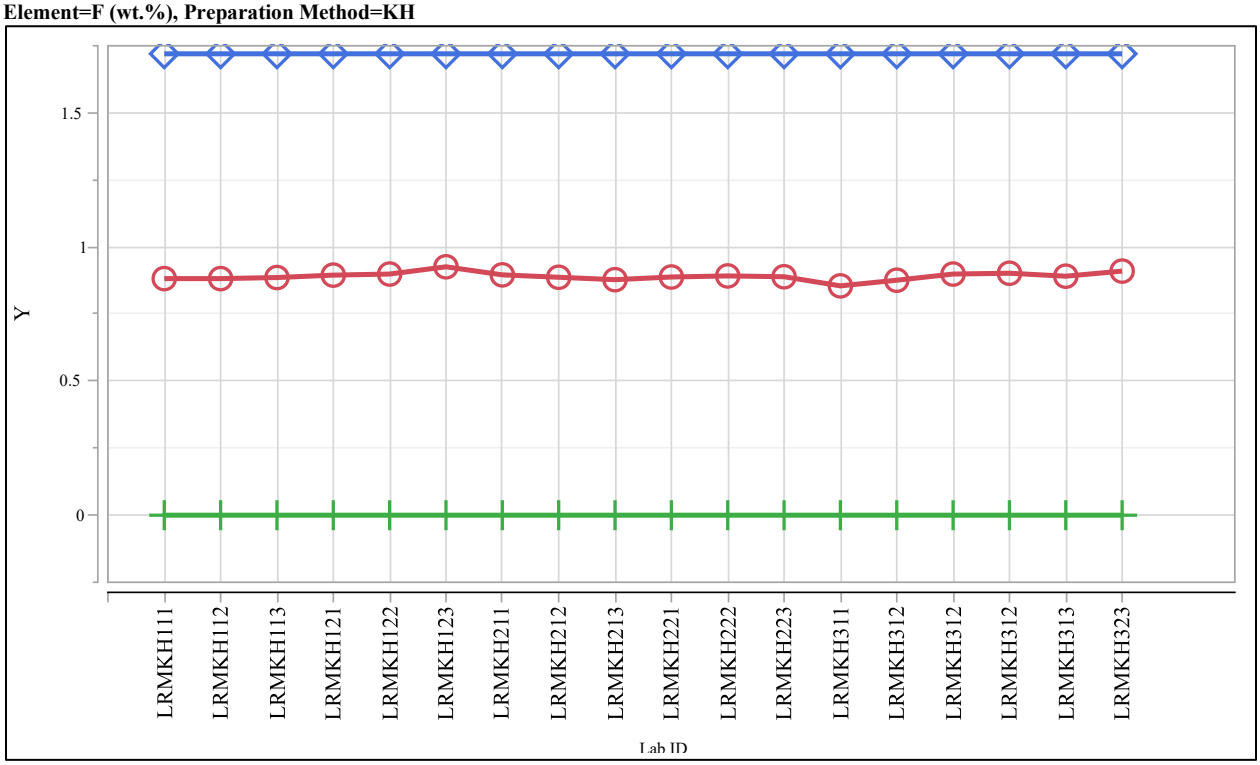
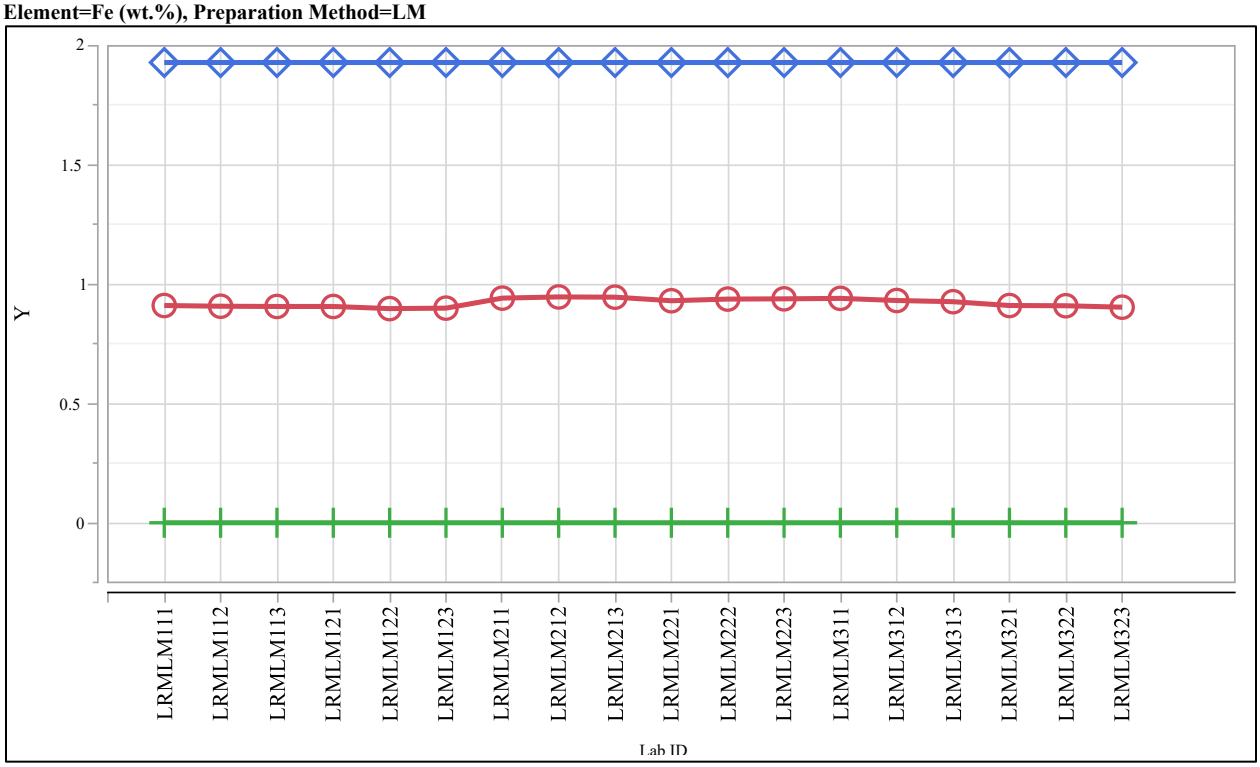


Exhibit A-3. Acceptability Evaluation for Measurements of the LRM Glass (continued)

Element=F (wt.%), Preparation Method=KH



Element=Fe (wt.%), Preparation Method=LM



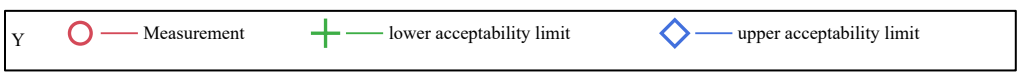
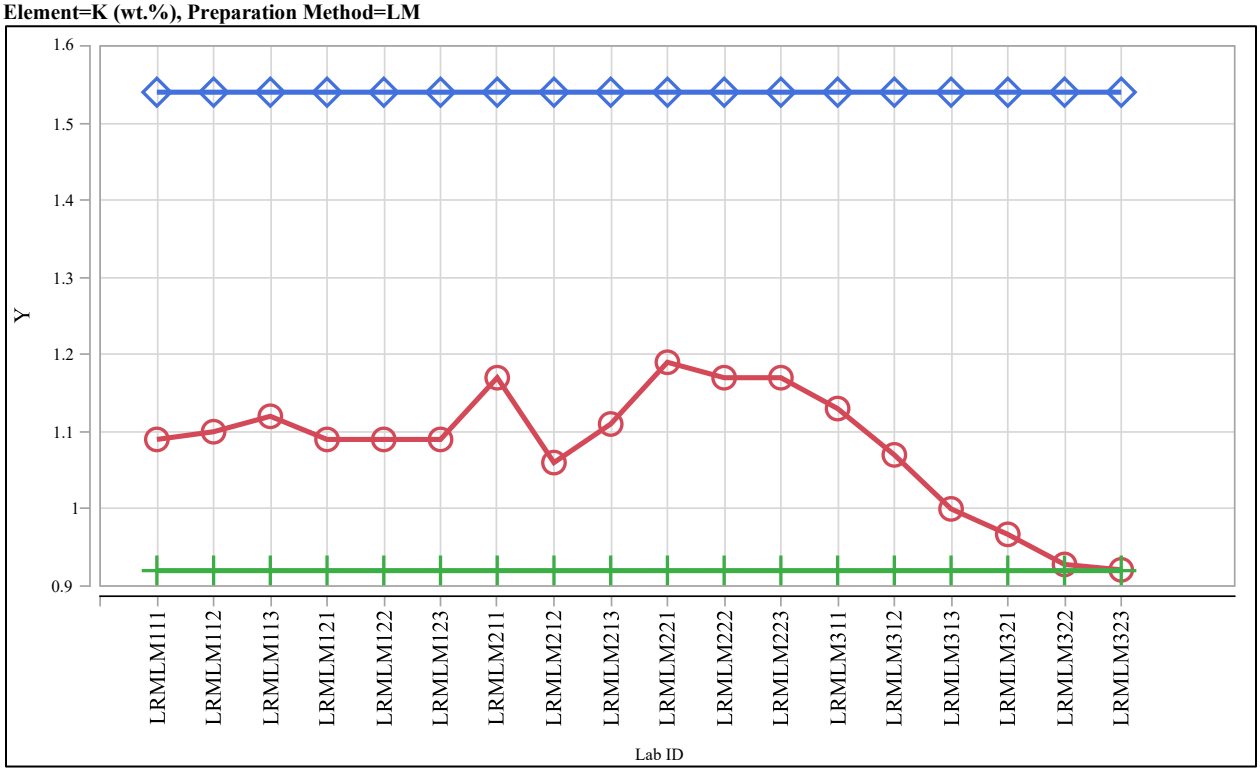
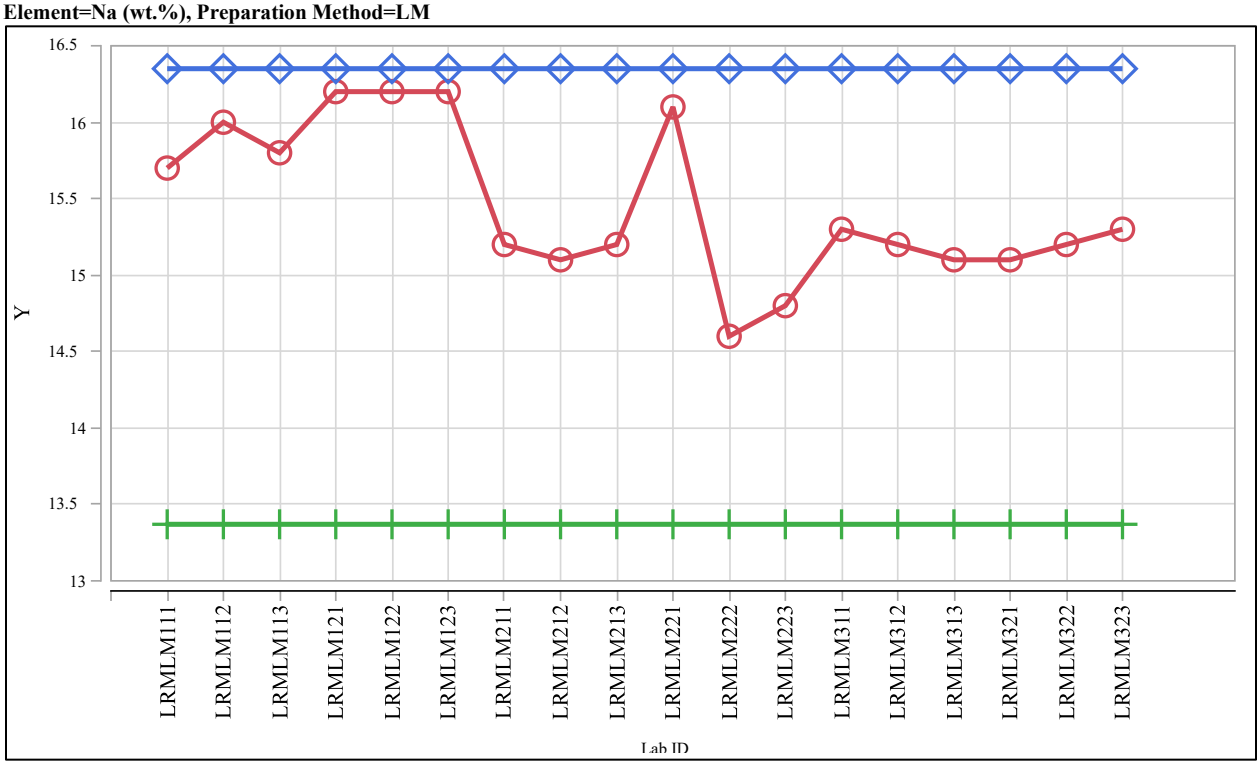


Exhibit A-3. Acceptability Evaluation for Measurements of the LRM Glass (continued)

Element=K (wt.%), Preparation Method=LM



Element=Na (wt.%), Preparation Method=LM



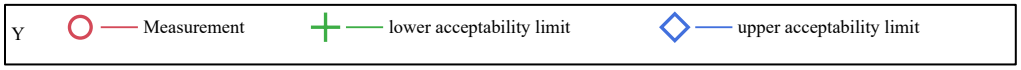
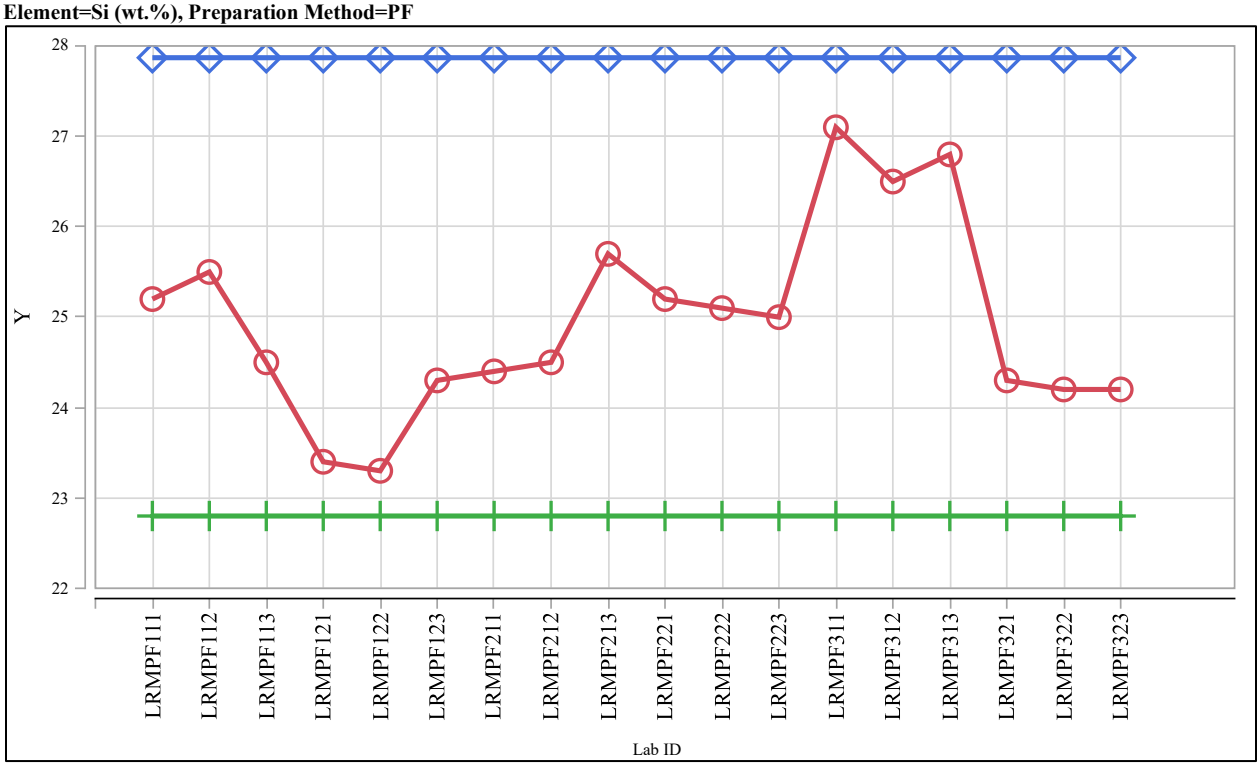
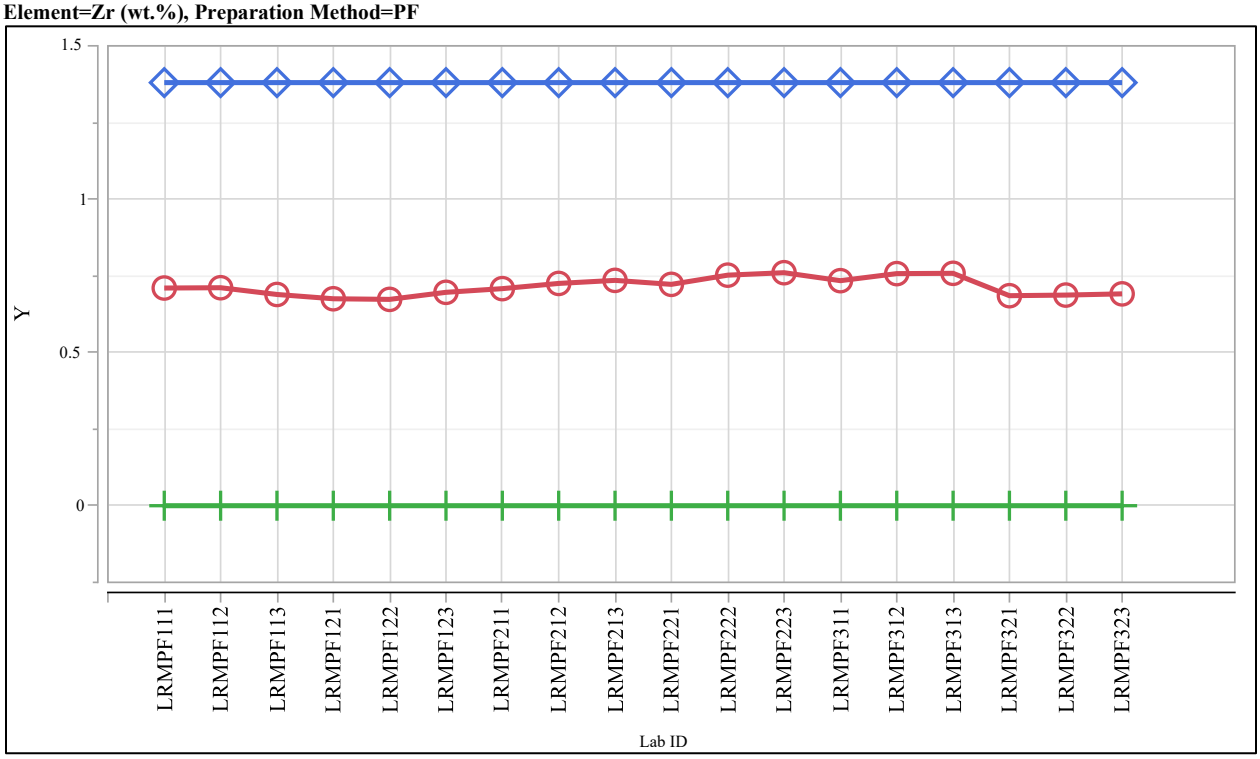


Exhibit A-3. Acceptability Evaluation for Measurements of the LRM Glass (continued)

Element=Si (wt.%), Preparation Method=PF



Element=Zr (wt.%), Preparation Method=PF



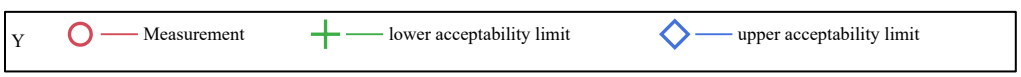
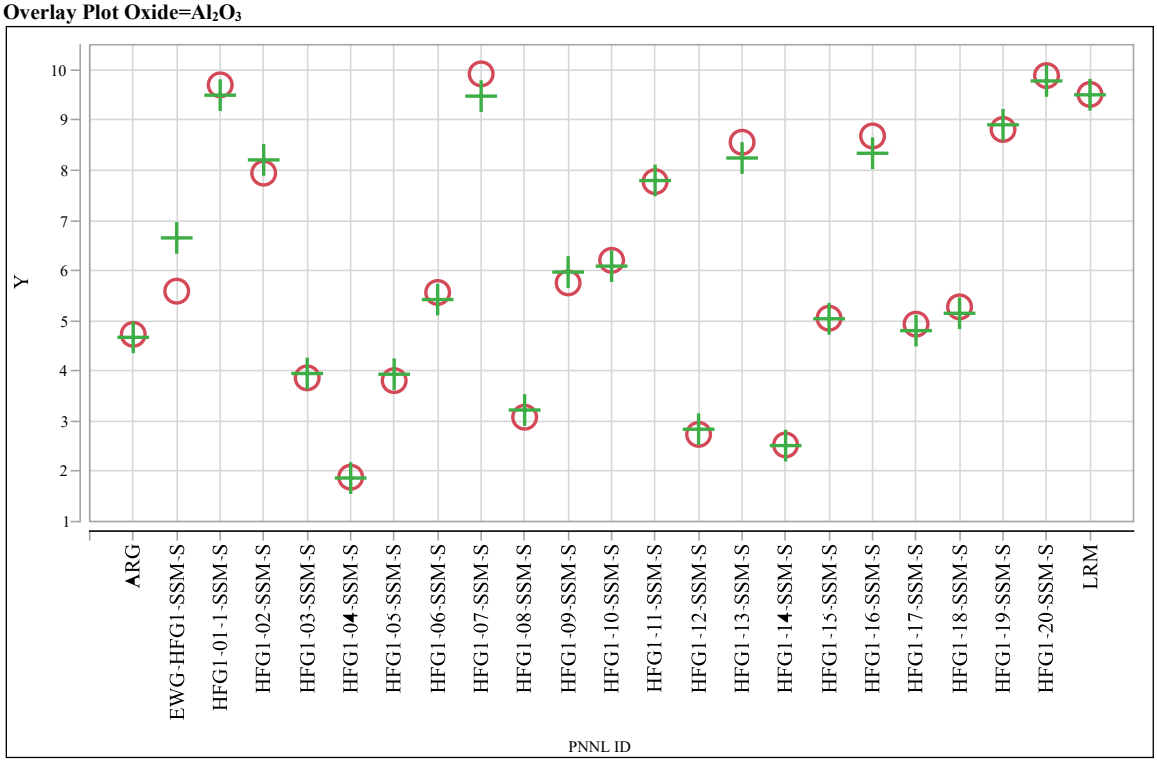


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide

Overlay Plot Oxide=Al_2O_3



Overlay Plot Oxide=B_2O_3

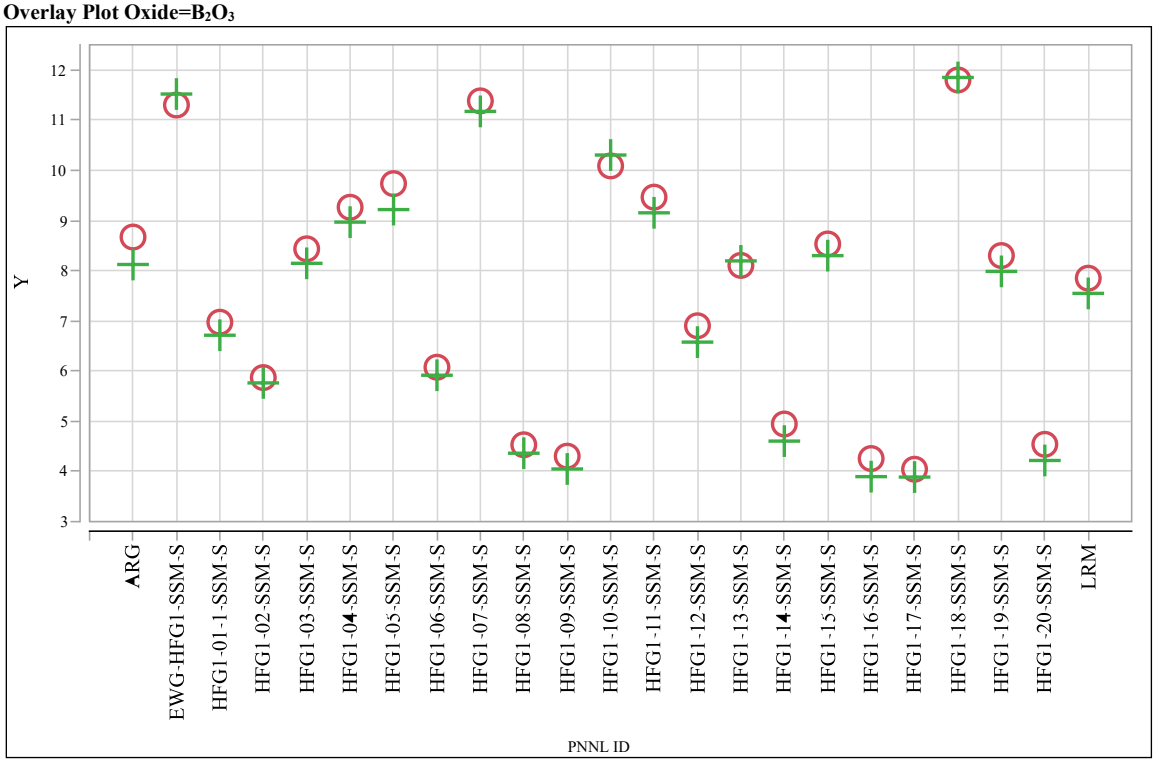
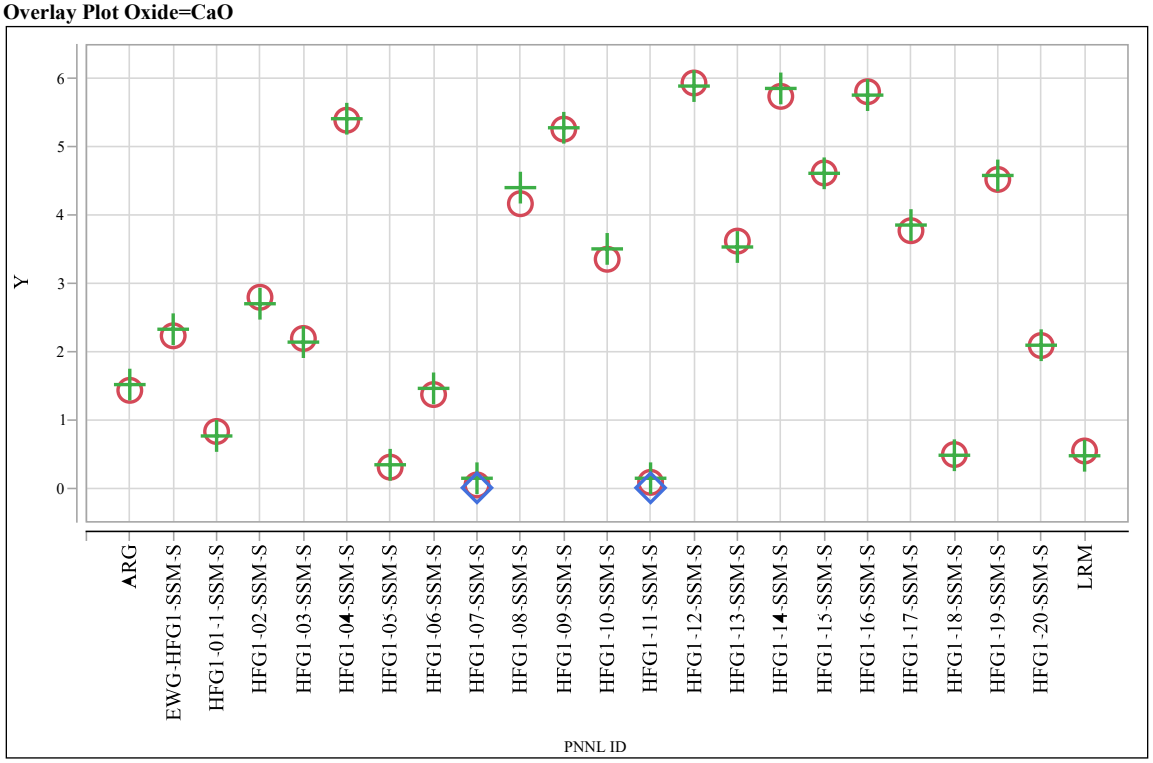
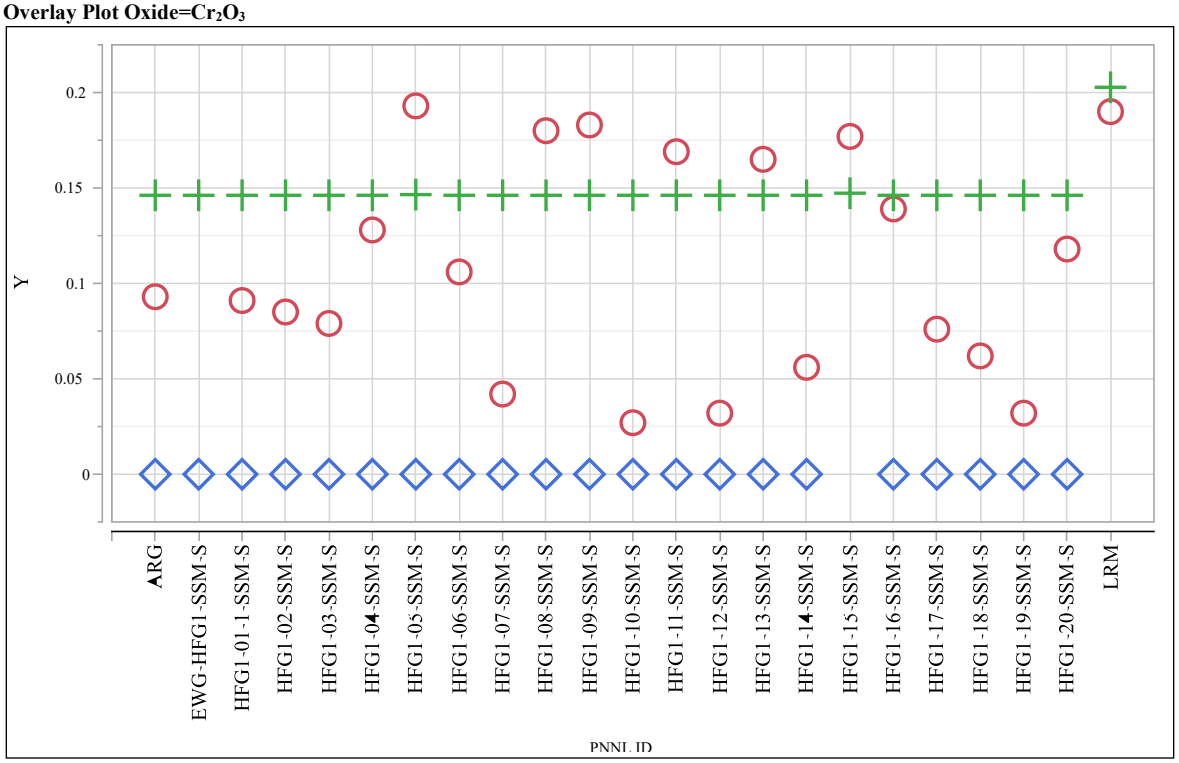


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

Overlay Plot Oxide=CaO



Overlay Plot Oxide=Cr_2O_3



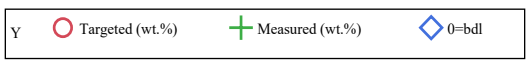
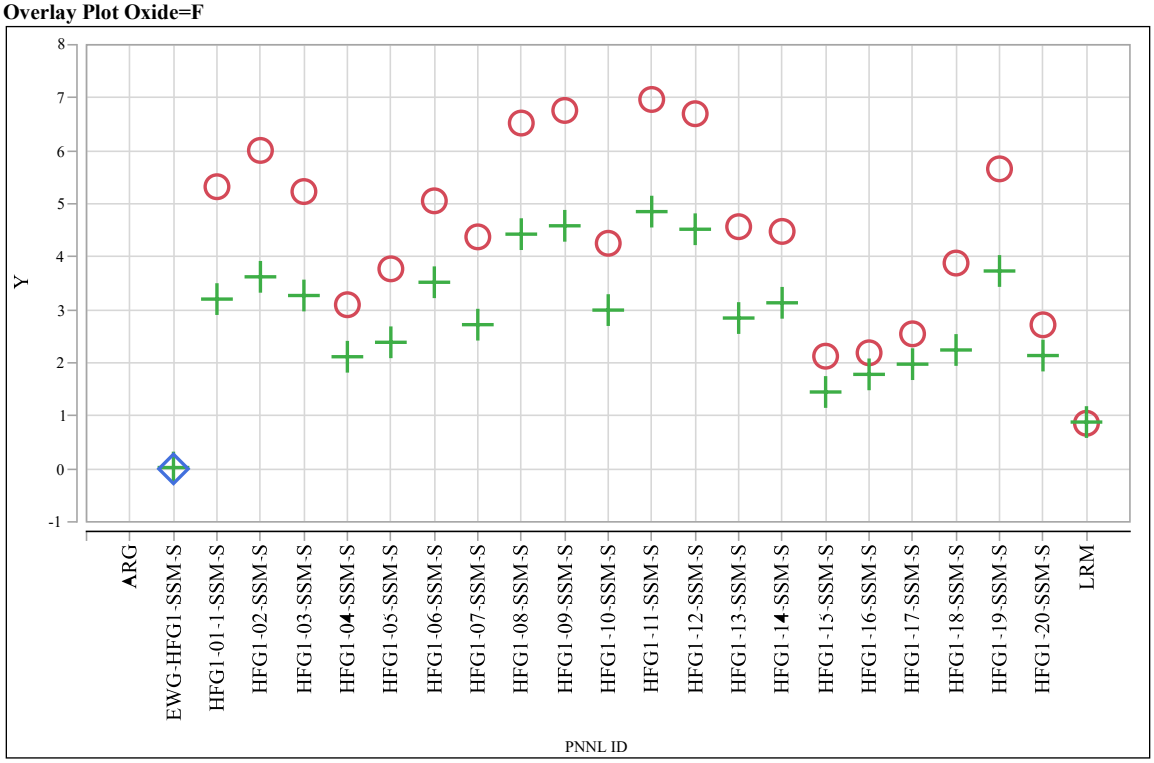


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

Overlay Plot Oxide=F



Overlay Plot Oxide=Fe_2O_3

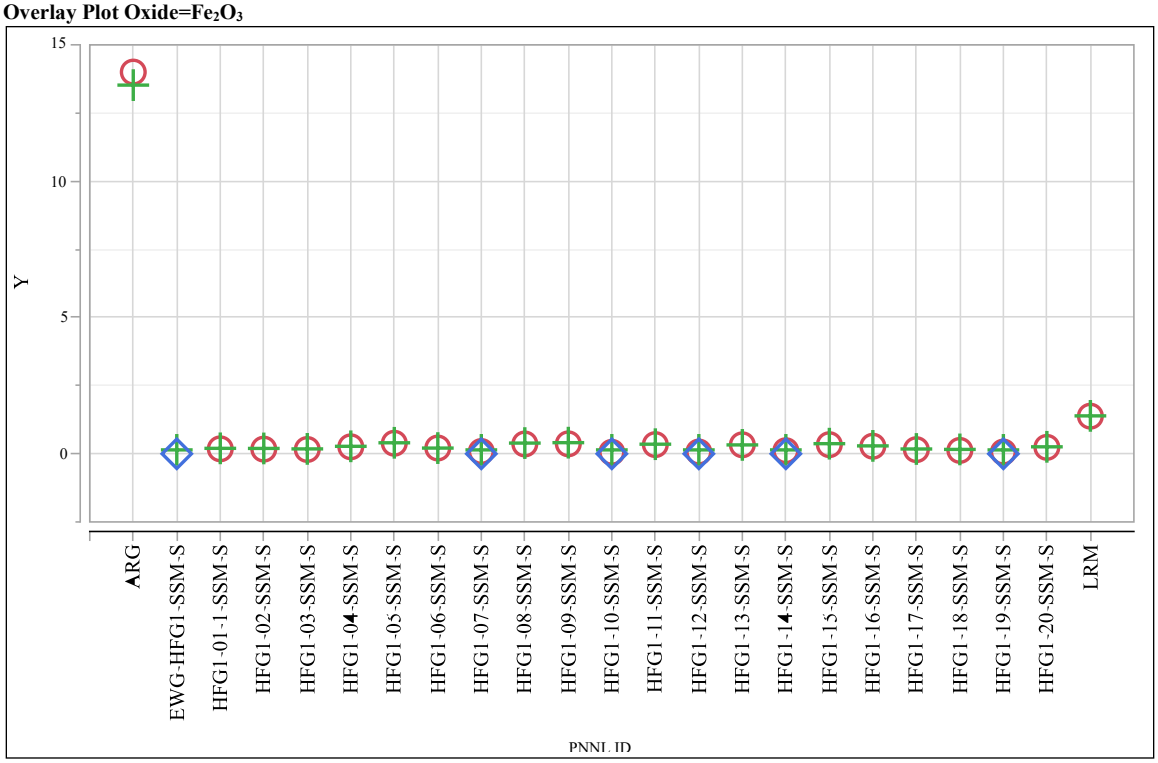
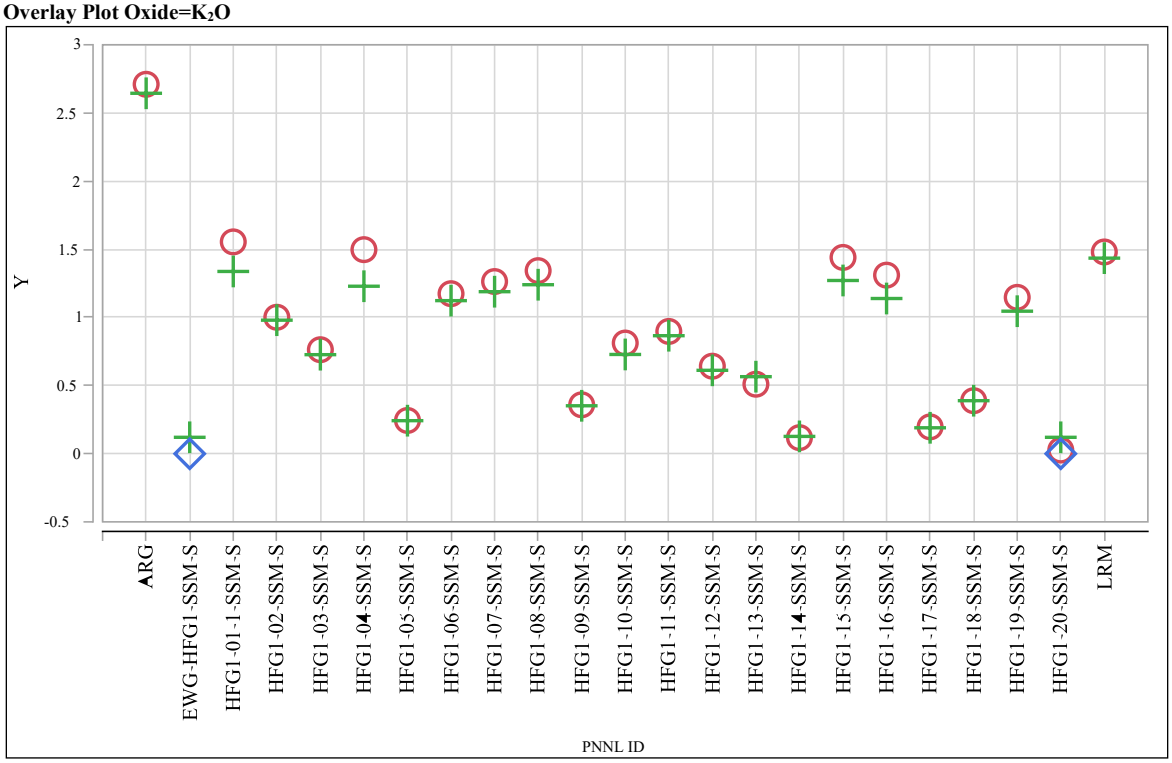
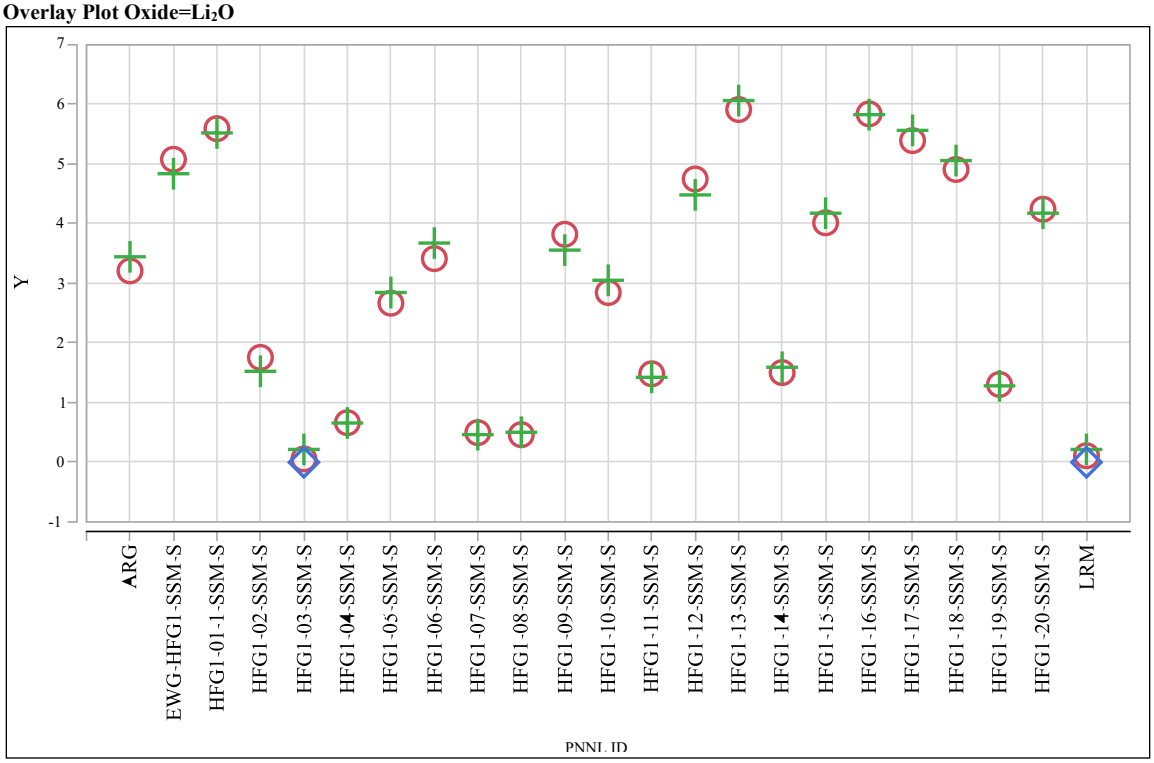


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

Overlay Plot Oxide=K_2O



Overlay Plot Oxide=Li_2O



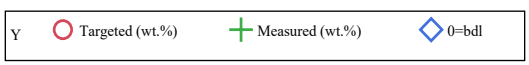
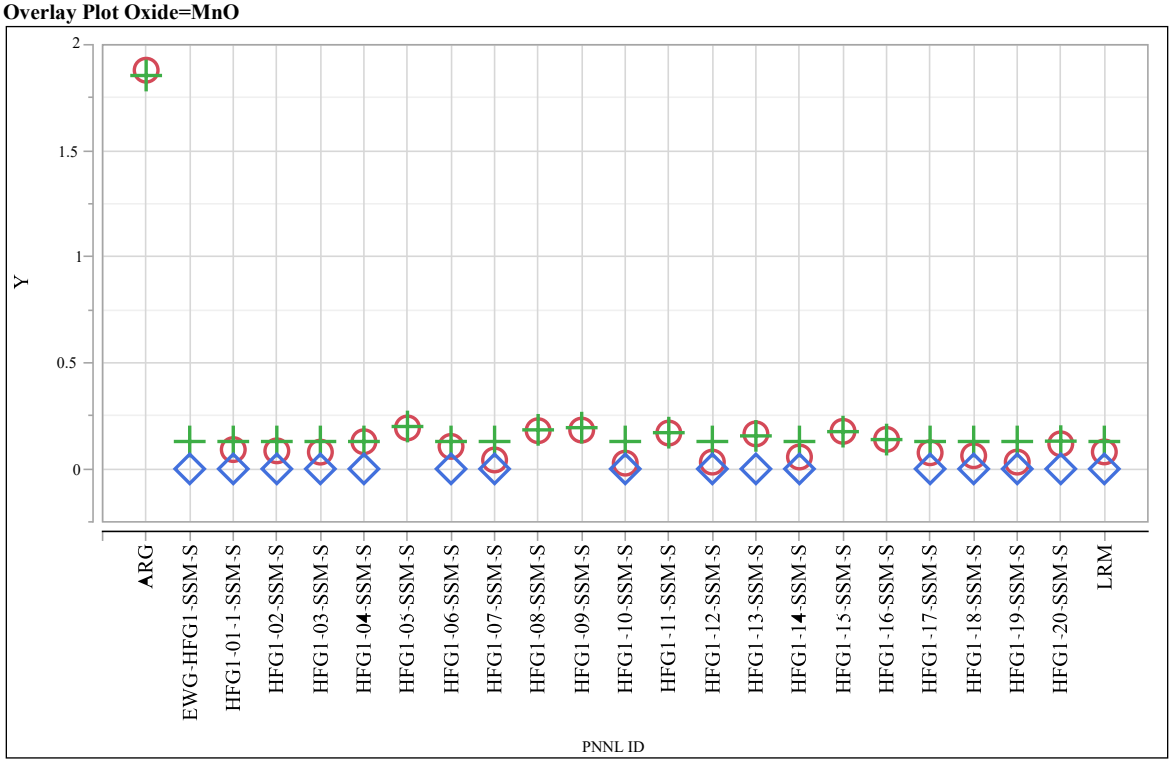
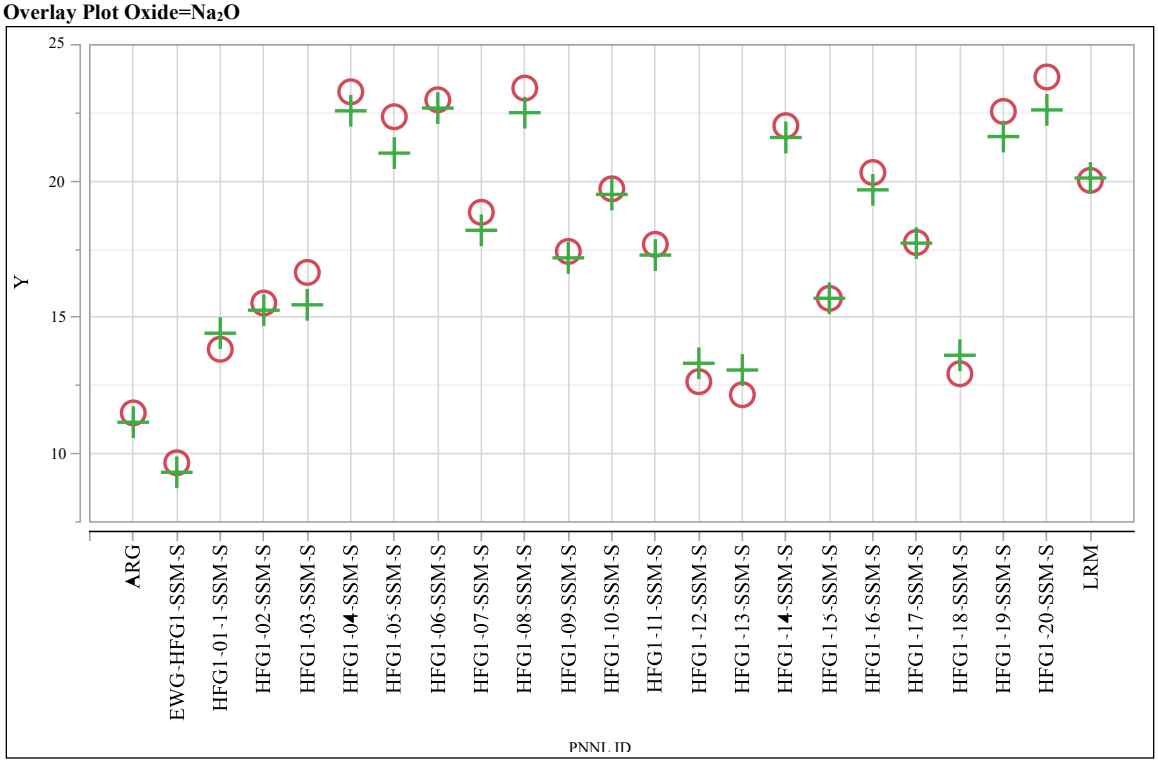


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

Overlay Plot Oxide=MnO



Overlay Plot Oxide=Na_2O



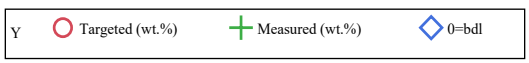
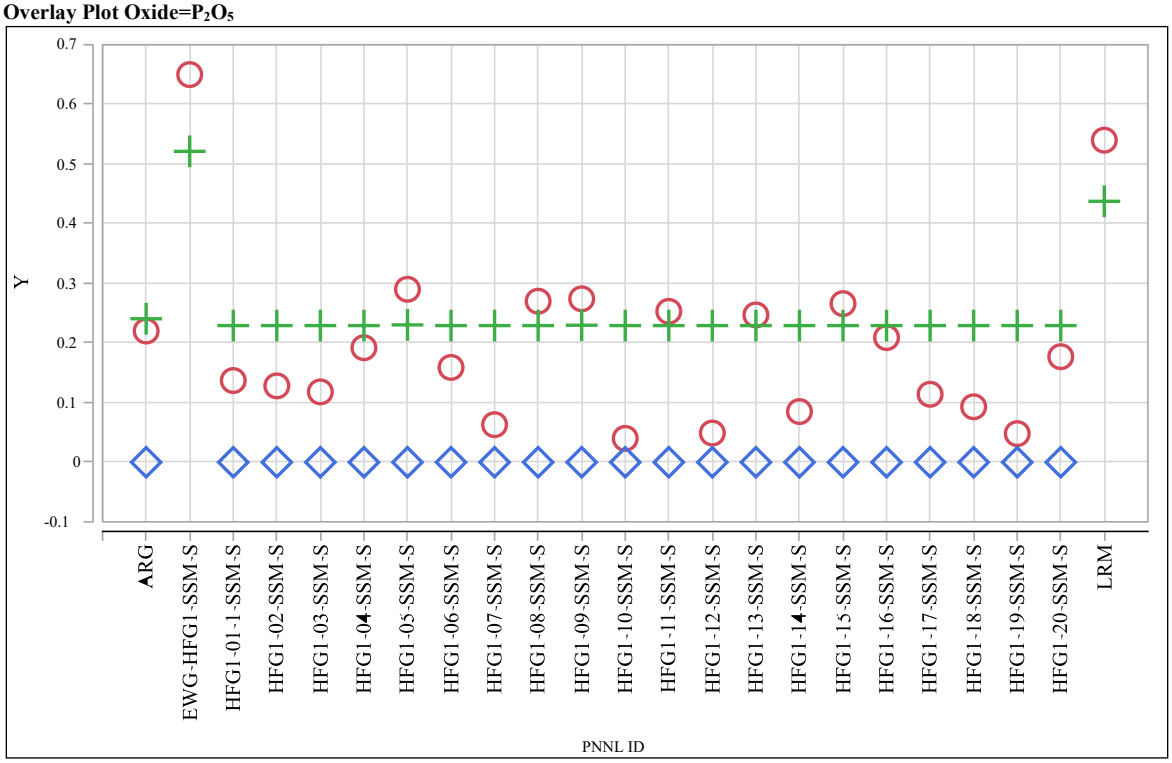
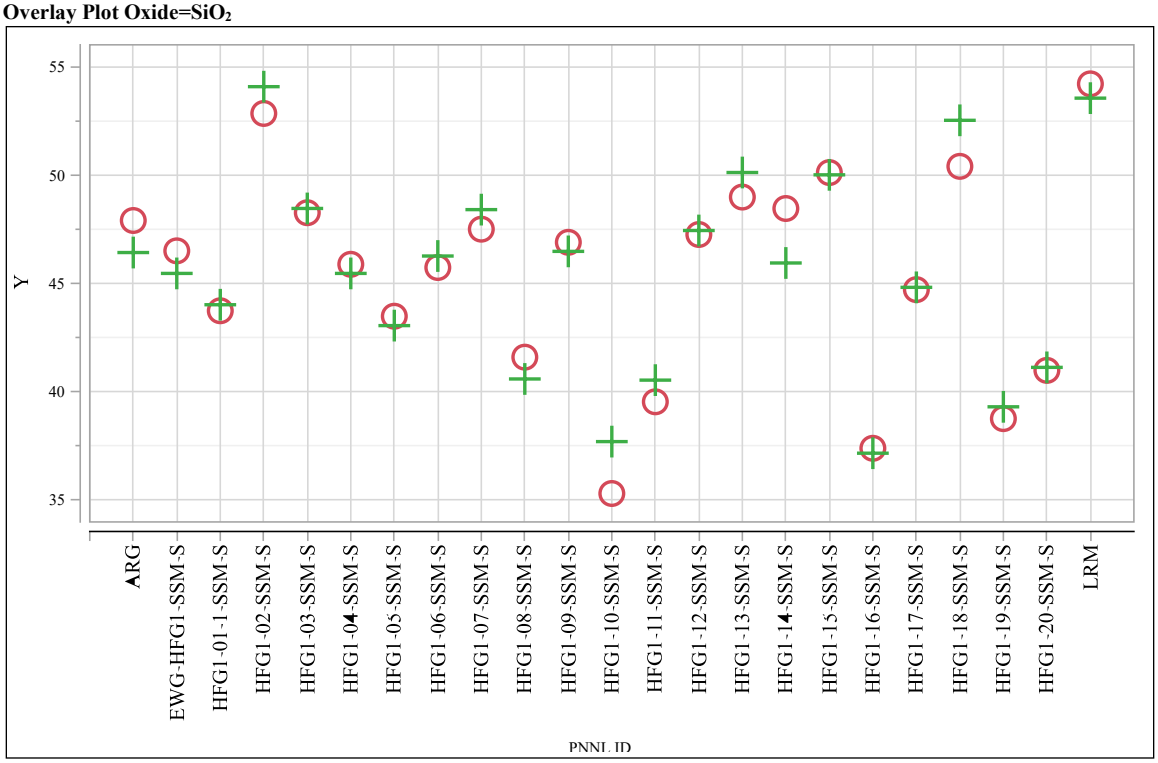


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

Overlay Plot Oxide=P_2O_5



Overlay Plot Oxide=SiO_2



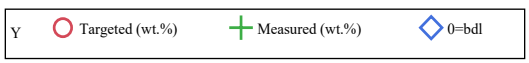
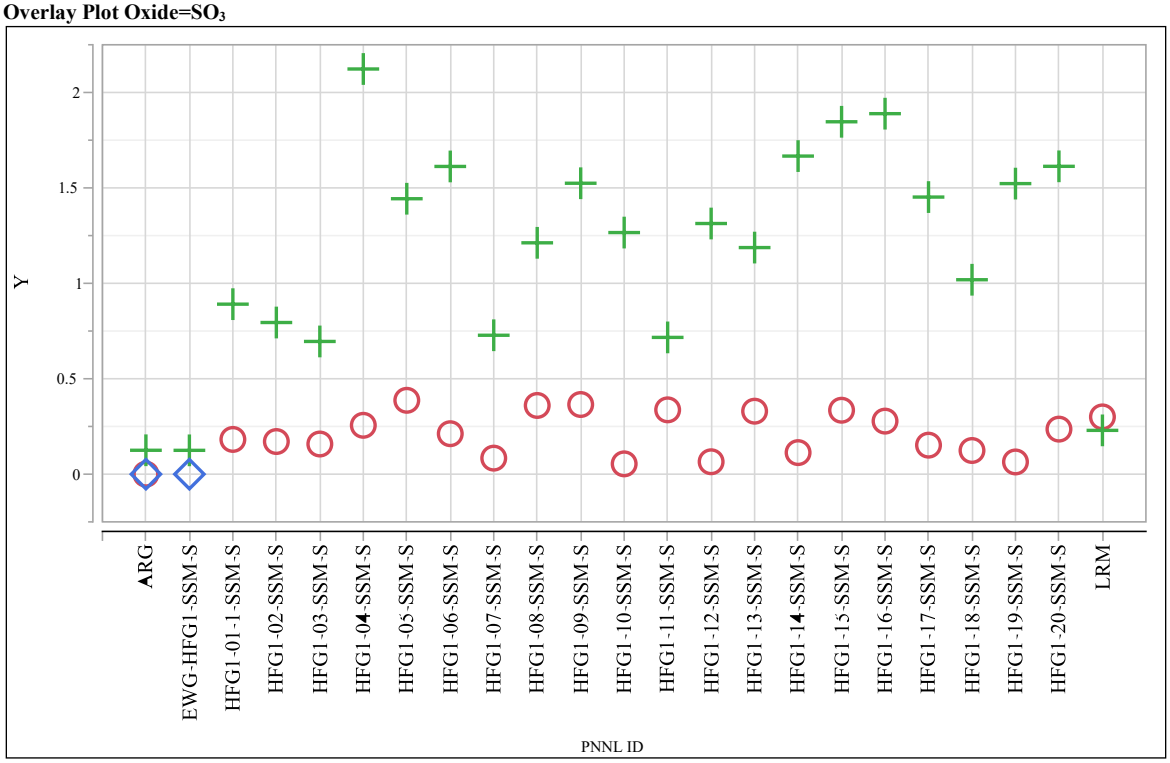
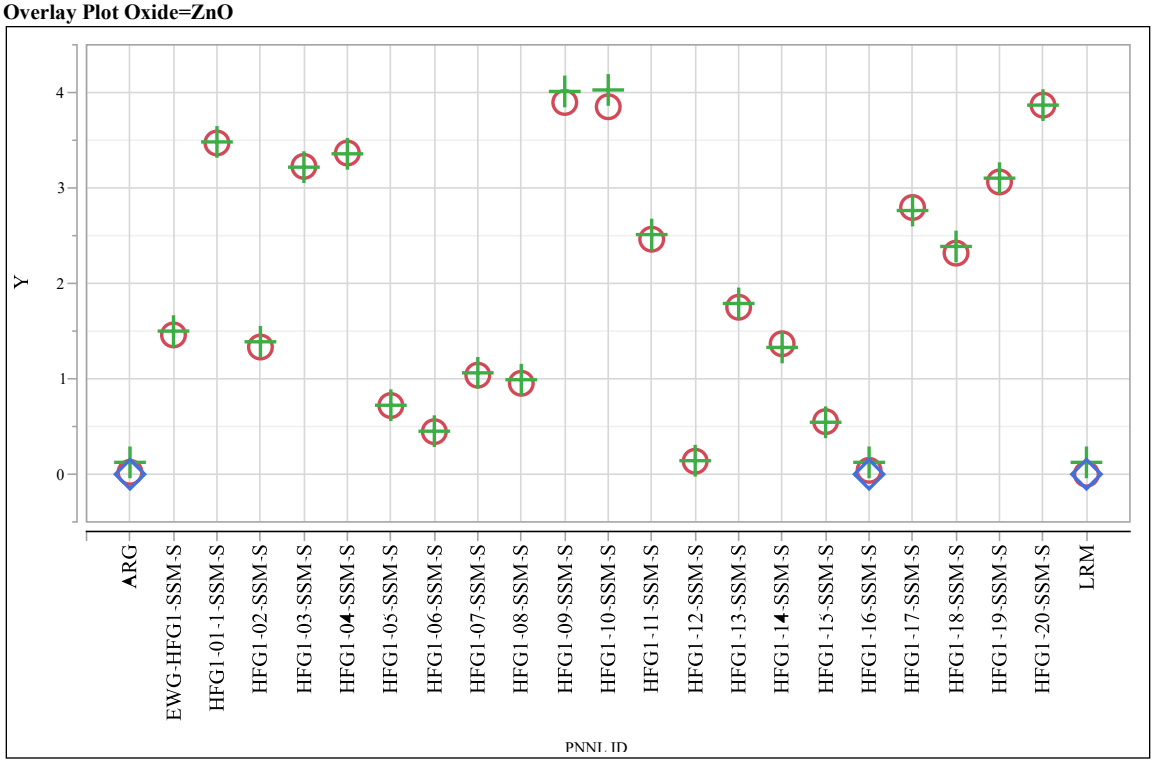


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

Overlay Plot Oxide=SO_3



Overlay Plot Oxide=ZnO



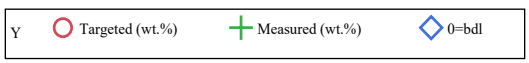
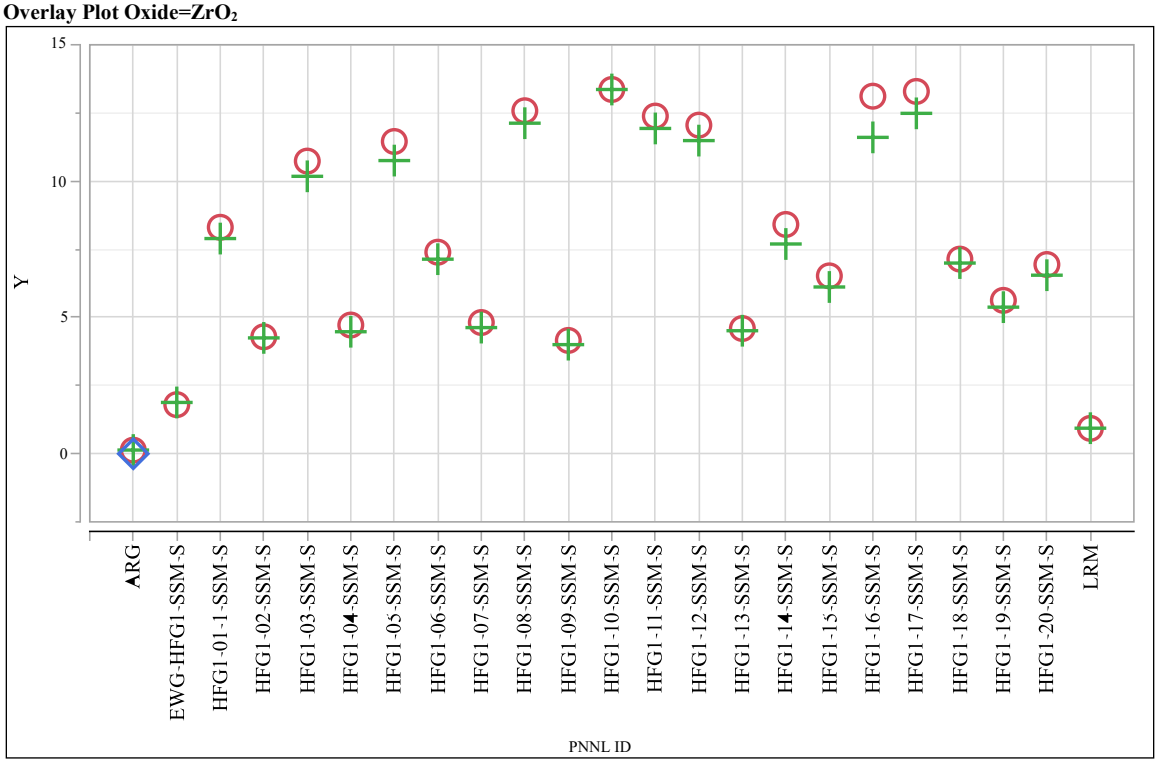
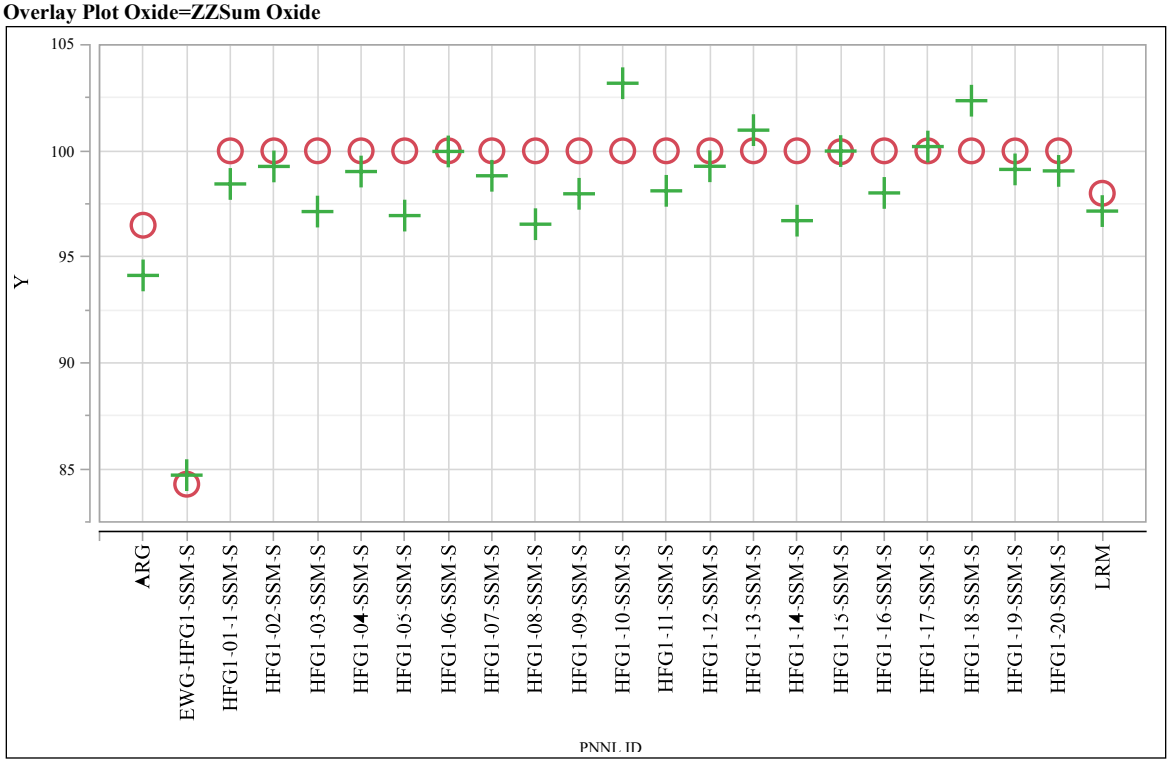


Exhibit A-4. Measured versus Targeted Concentrations by Glass ID by Oxide (continued)

Overlay Plot Oxide=ZrO_2



Overlay Plot Oxide=ZZSum Oxide



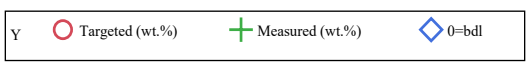
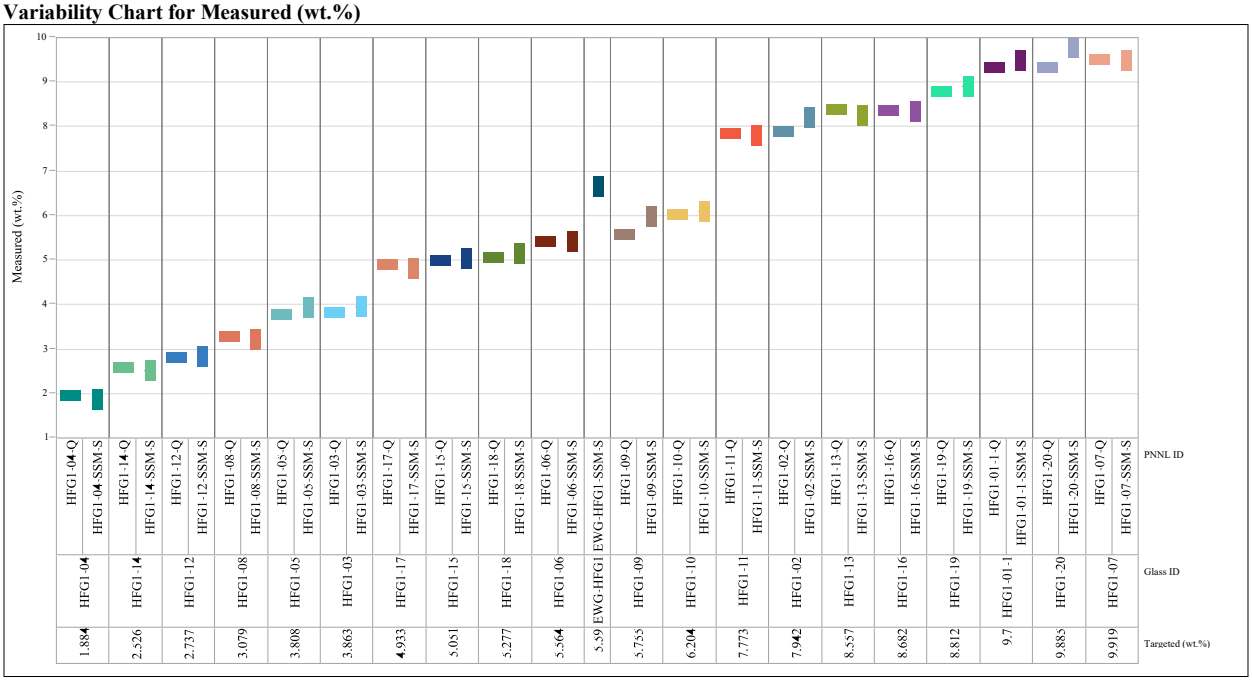


Exhibit A-5. Comparisons of the Measured Compositions of the Quenched and SSM Versions of the Study Glasses

Oxide=Al_2O_3
Variability Chart for Measured (wt.%)



Oxide=B_2O_3
Variability Chart for Measured (wt.%)

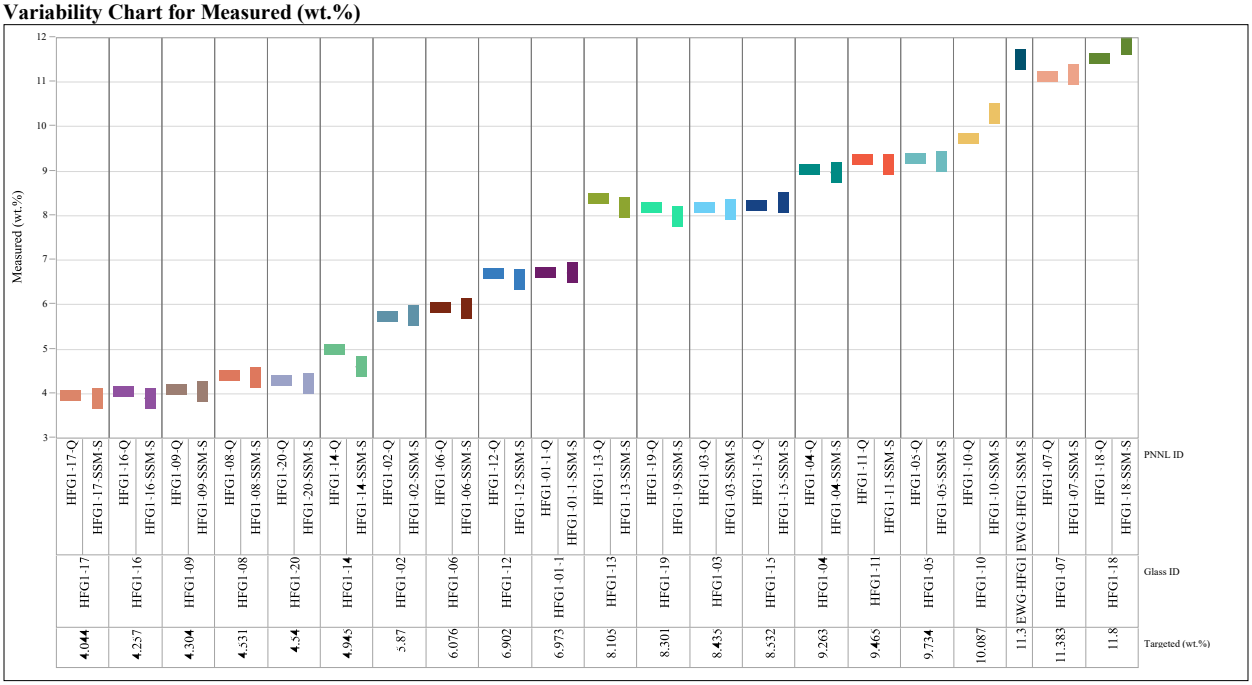
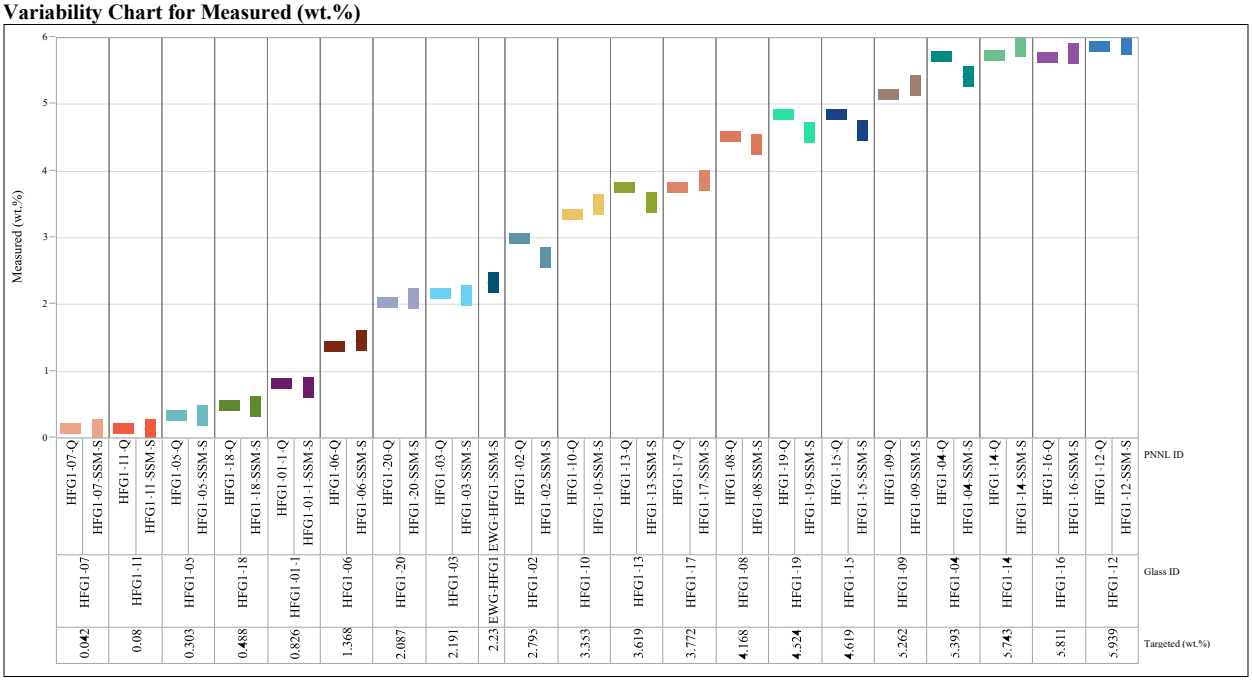


Exhibit A-5. Comparisons of the Measured Compositions of the Quenched and SSM Versions of the Study Glasses (continued)

Oxide=CaO
Variability Chart for Measured (wt.%)



Oxide=Cr_2O_3
Variability Chart for Measured (wt.%)

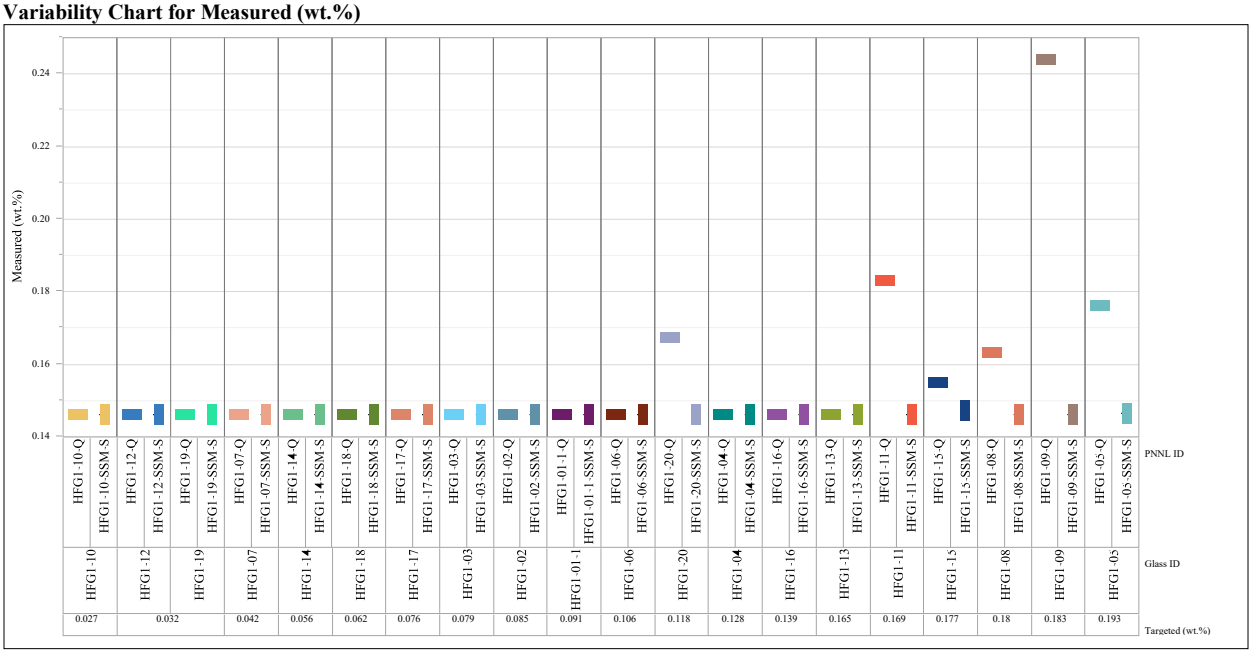
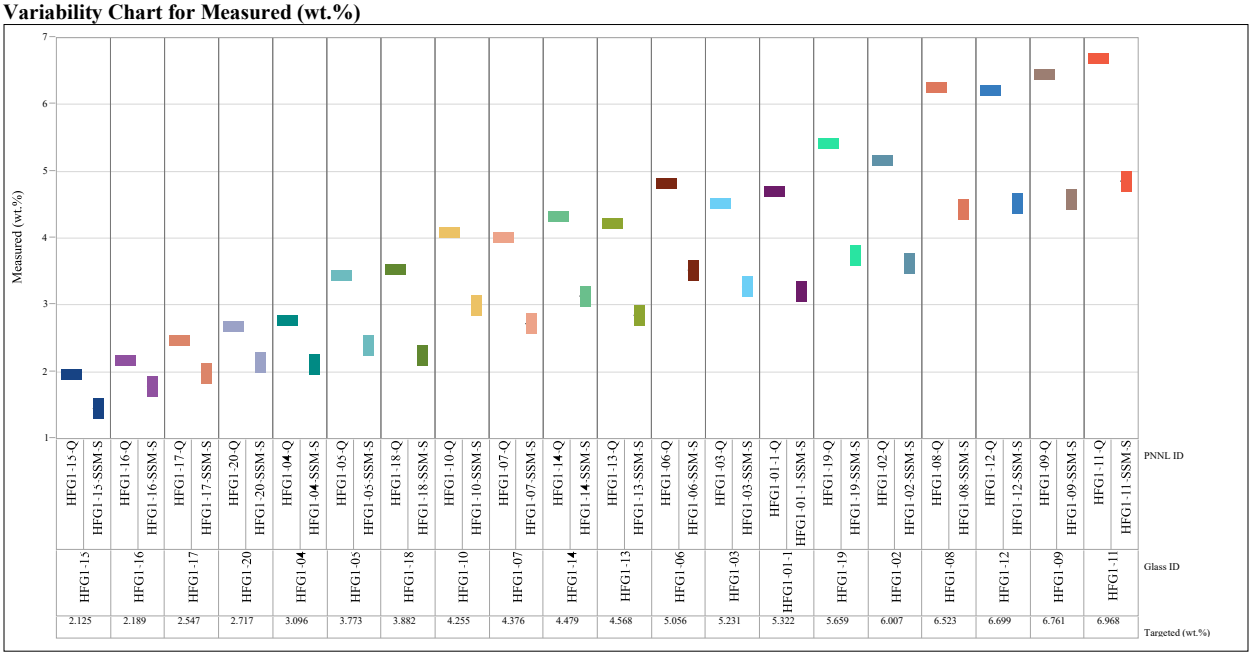


Exhibit A-5. Comparisons of the Measured Compositions of the Quenched and SSM Versions of the Study Glasses (continued)

Oxide=F
Variability Chart for Measured (wt.%)



Oxide=Fe_2O_3
Variability Chart for Measured (wt.%)

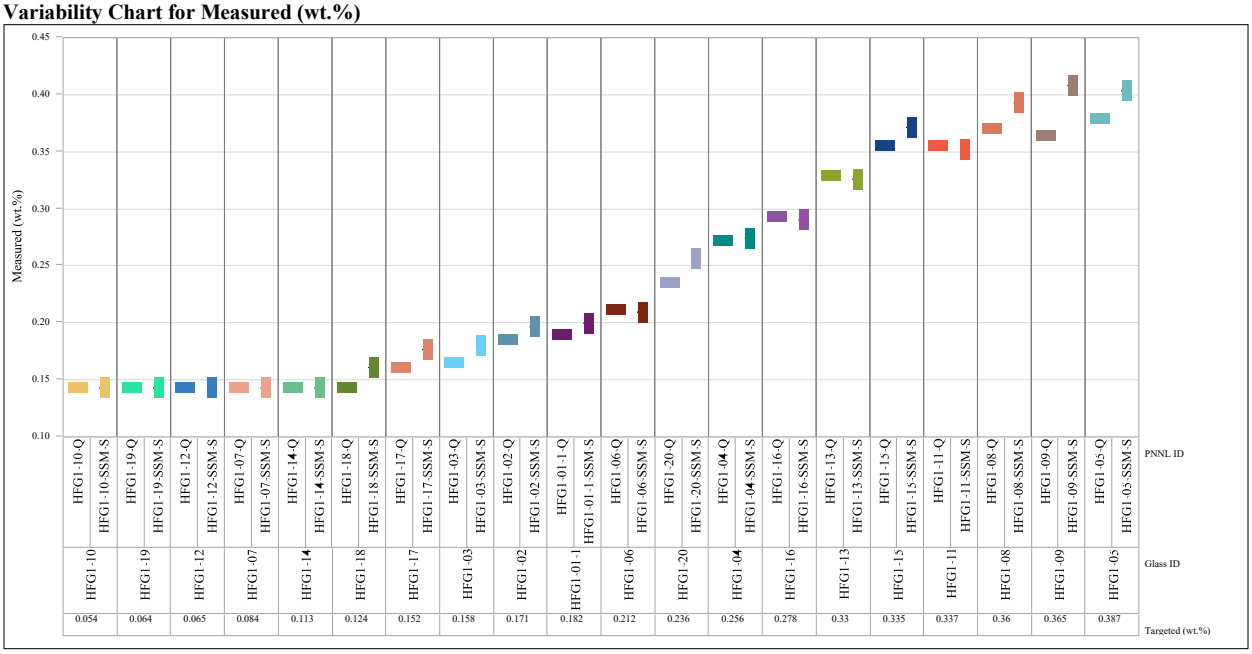
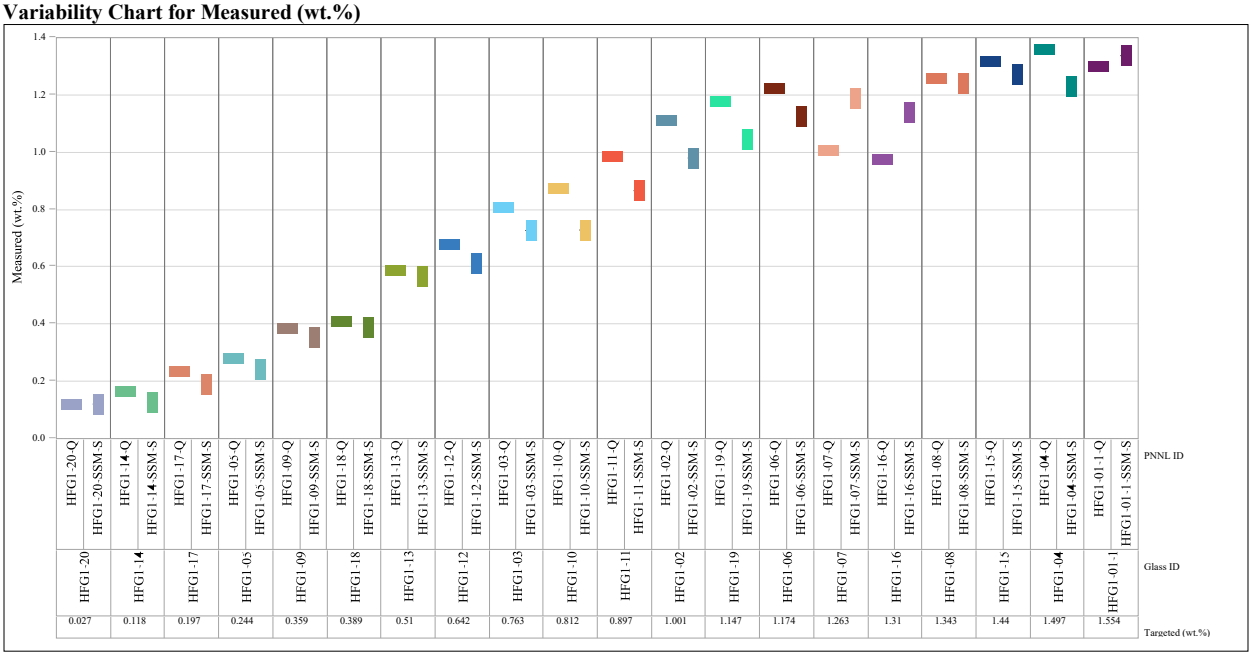


Exhibit A-5. Comparisons of the Measured Compositions of the Quenched and SSM Versions of the Study Glasses (continued)

Oxide=K_2O
Variability Chart for Measured (wt.%)



Oxide=Li_2O
Variability Chart for Measured (wt.%)

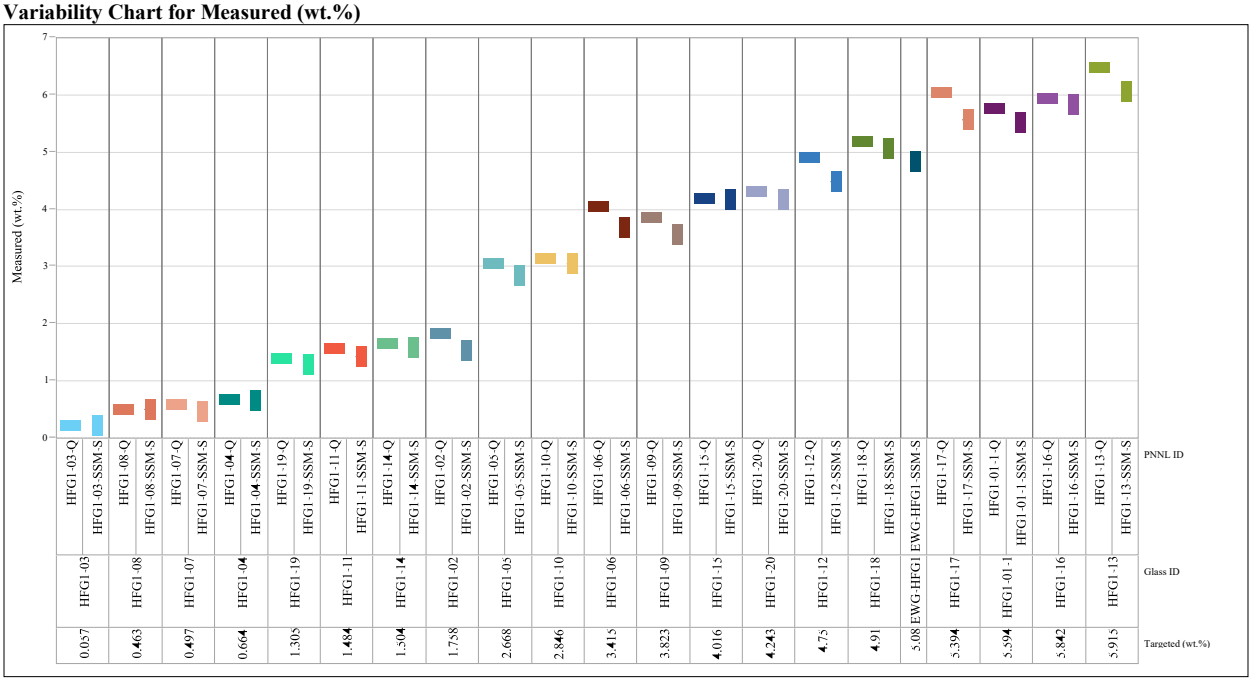
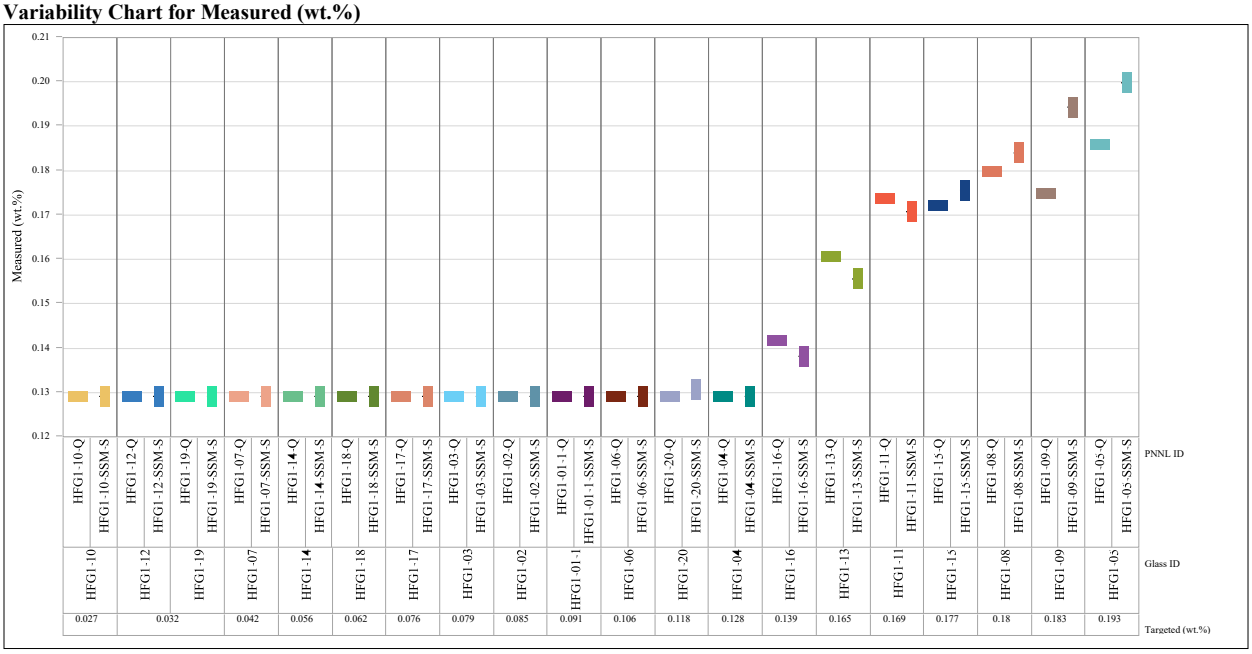


Exhibit A-5. Comparisons of the Measured Compositions of the Quenched and SSM Versions of the Study Glasses (continued)

Oxide=MnO
Variability Chart for Measured (wt.%)



Oxide=Na_2O
Variability Chart for Measured (wt.%)

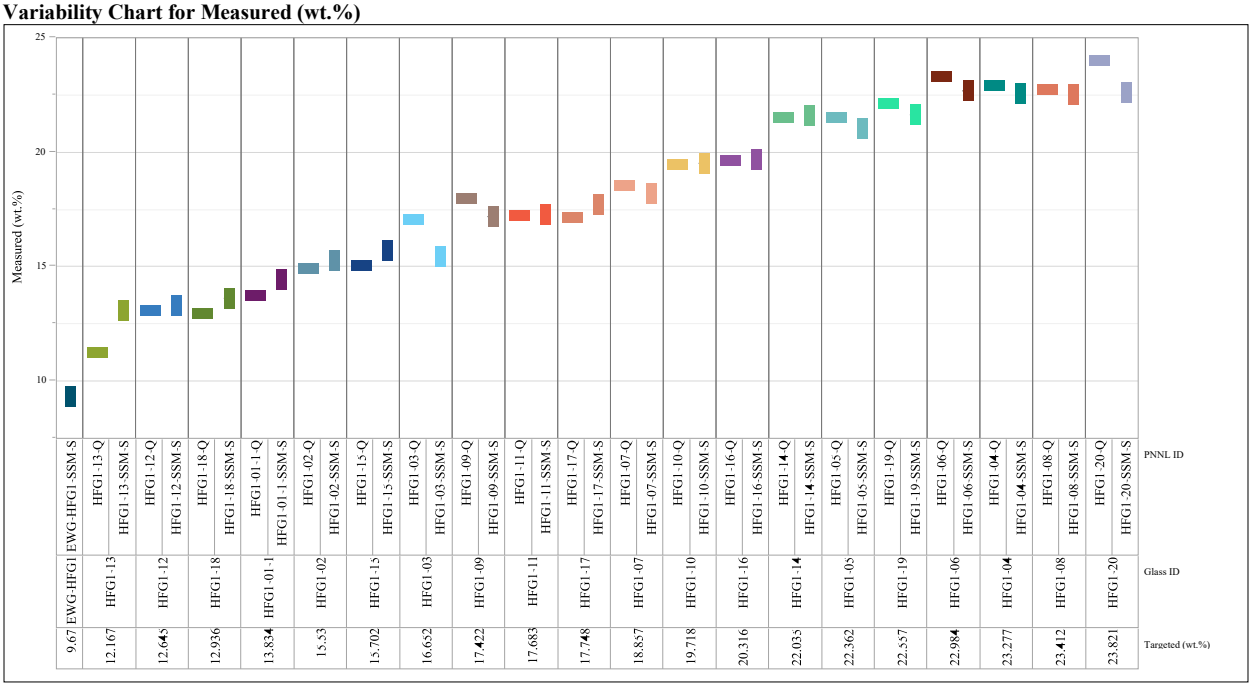
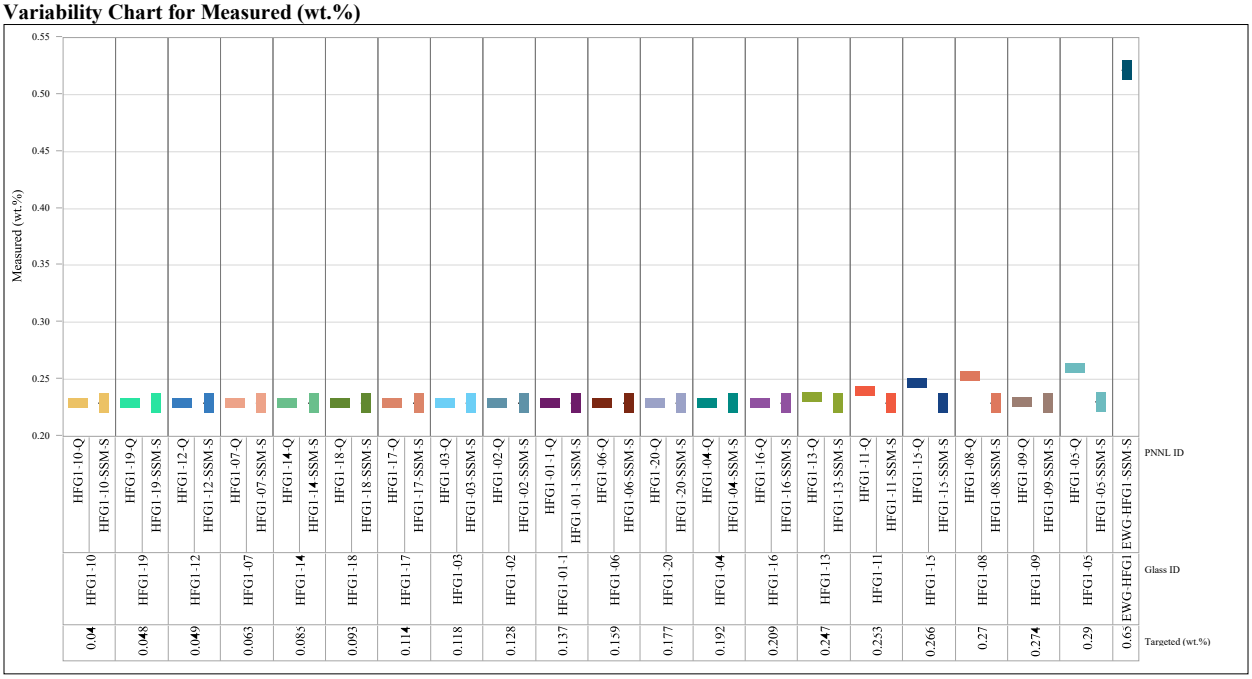


Exhibit A-5. Comparisons of the Measured Compositions of the Quenched and SSM Versions of the Study Glasses (continued)

Oxide=P_2O_5
Variability Chart for Measured (wt.%)



Oxide=SiO_2
Variability Chart for Measured (wt.%)

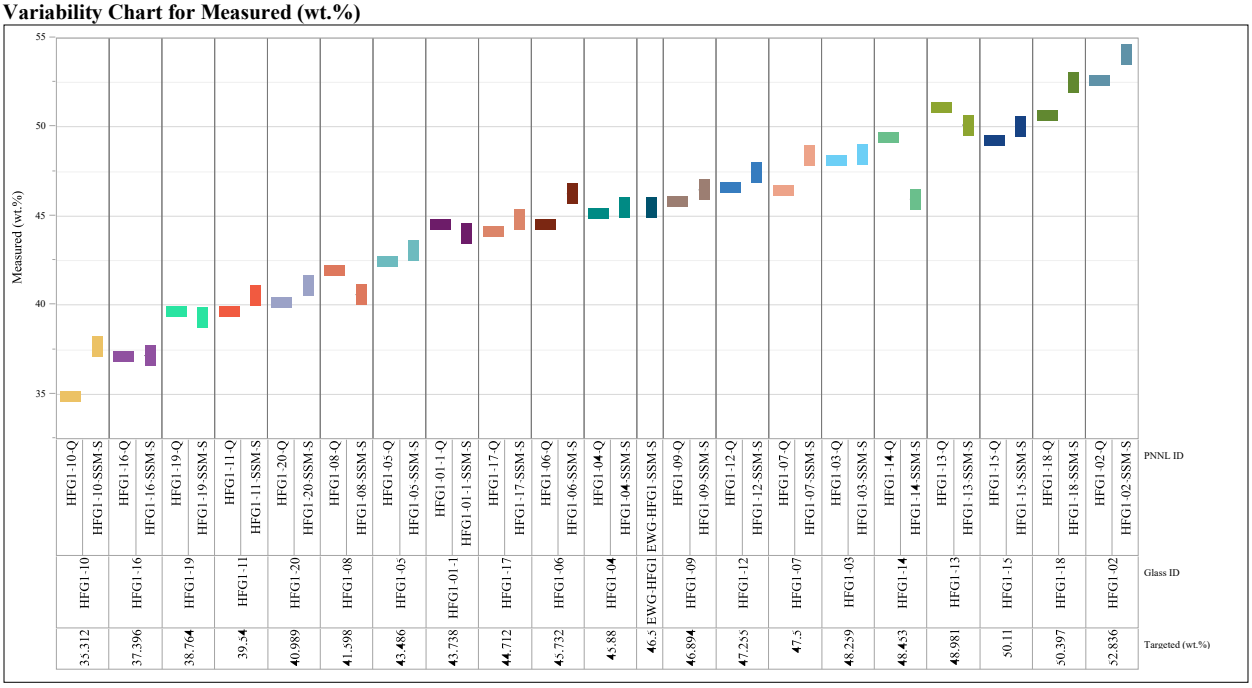
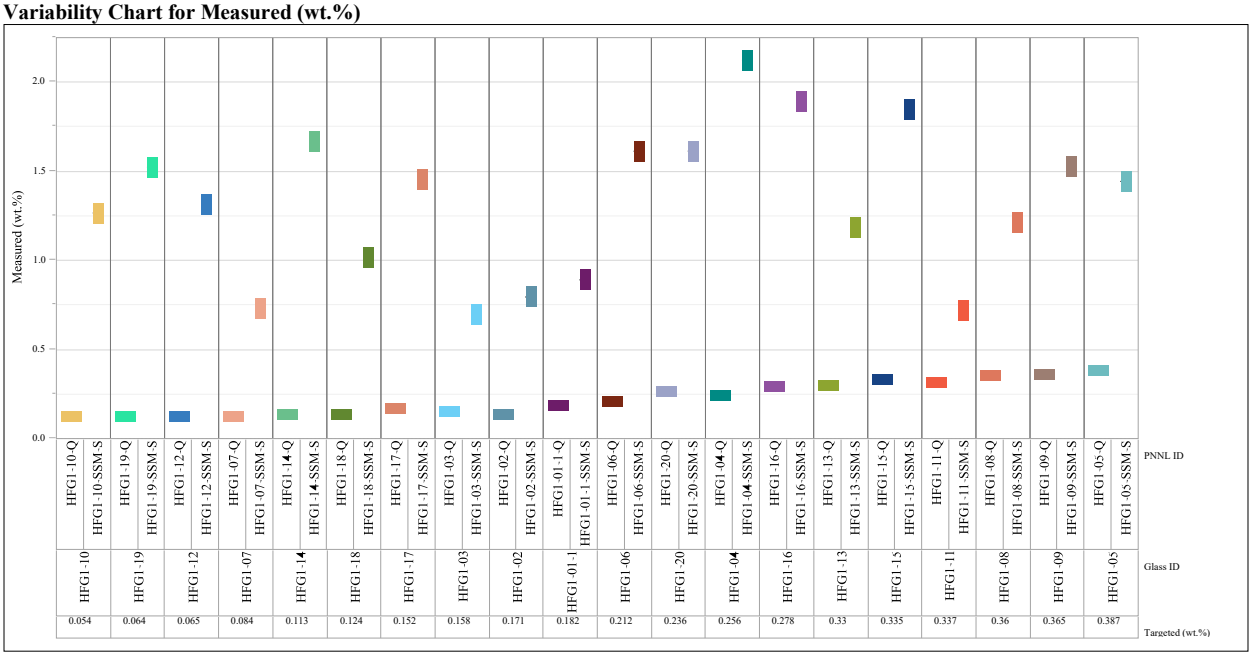


Exhibit A-5. Comparisons of the Measured Compositions of the Quenched and SSM Versions of the Study Glasses (continued)

Oxide=SO_3
Variability Chart for Measured (wt.%)



Oxide=ZnO
Variability Chart for Measured (wt.%)

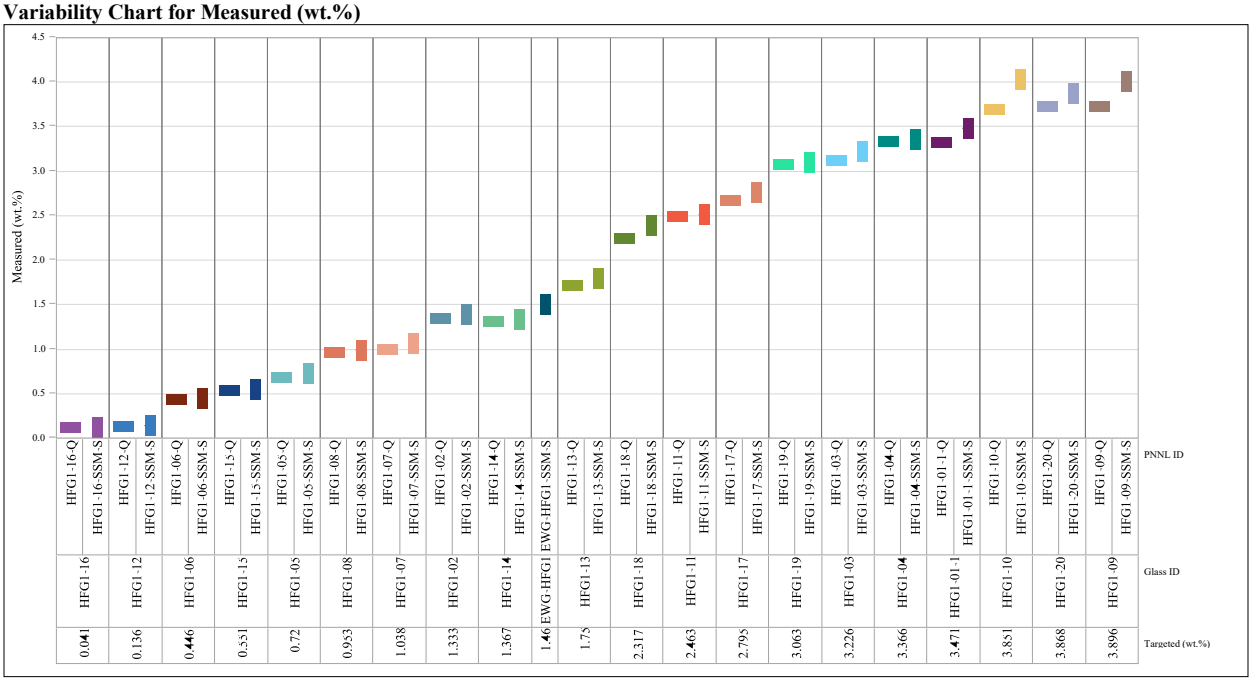
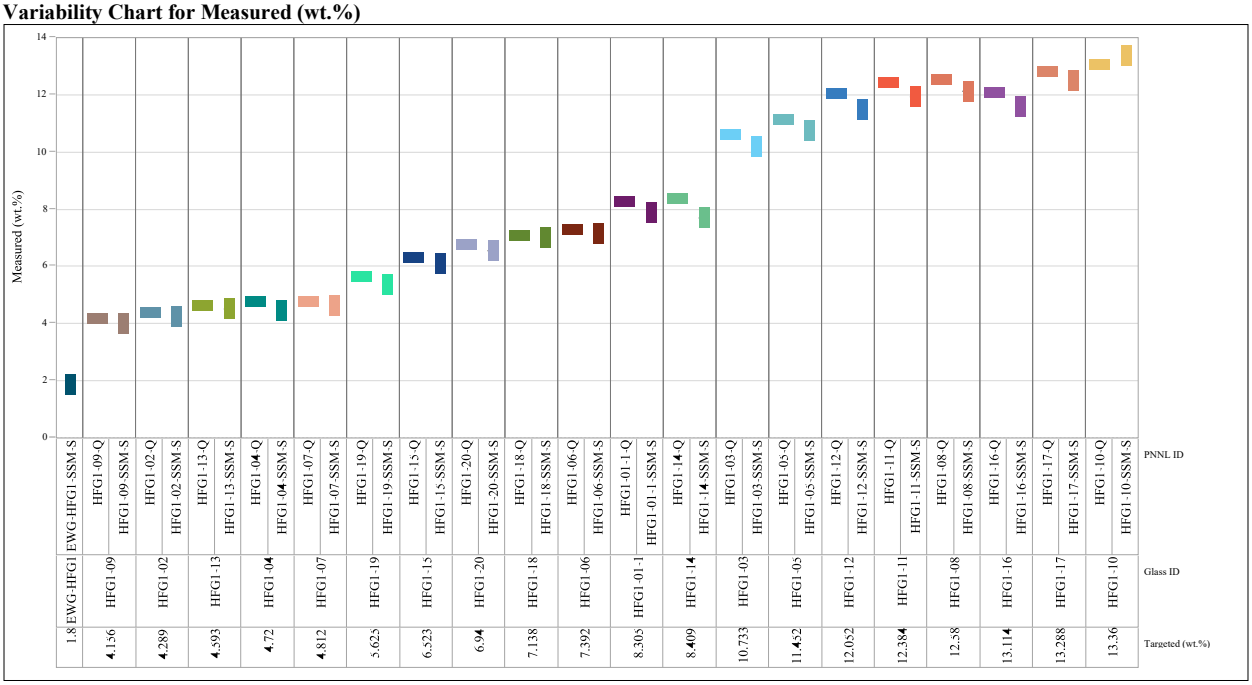
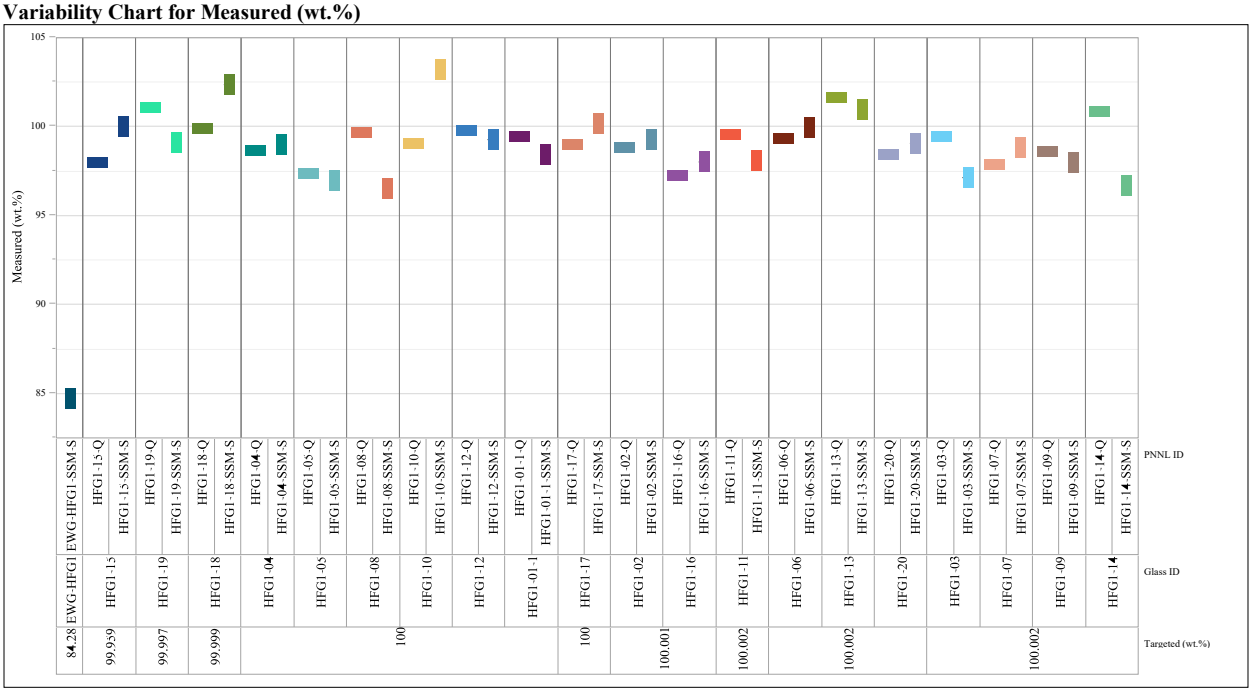


Exhibit A-5. Comparisons of the Measured Compositions of the Quenched and SSM Versions of the Study Glasses (continued)

Oxide=ZrO_2
Variability Chart for Measured (wt.%)



Oxide=Sum Oxide
Variability Chart for Measured (wt.%)



Appendix B. Tables and Exhibits Supporting the Wash Solution Composition Measurements

Table B-1. Measurements (mg/L) of Wash Solutions Measured by ICP-OES

Solution ID	Block	Seq	Lab ID	Al	B	Ca	Cr	Fe	K	Li	Mn	Na	P	S	Si	Zn	Zr
soln std	1	1	soln std-11	3.80	19.5	<1.00	<1.00	4.07	9.85	9.51	<1.00	79.6	<1.00	<1.00	52.4	<1.00	<1.00
HFG1-04-SSM-W	1	2	S-11788-1	<1.00	17.9	3.83	7.88	<1.00	55.4	4.00	<1.00	734	<1.00	408	19.8	<1.00	<1.00
HFG1-02-SSM-W	1	3	S-11786-1	<1.00	11.1	4.78	2.57	<1.00	41.2	69.2	<1.00	1020	<1.00	619	5.01	<1.00	<1.00
HFG1-12-SSM-W	1	4	S-11796-1	<1.00	11.0	1.51	1.24	<1.00	25.5	106	<1.00	652	<1.00	473	7.56	<1.00	<1.00
HFG1-03-SSM-W	1	5	S-11787-1	<1.00	11.8	11.3	2.20	<1.00	29.8	1.46	<1.00	978	<1.00	580	3.30	<1.00	<1.00
HFG1-17-SSM-W	1	6	S-11801-1	<1.00	6.59	<1.00	4.51	<1.00	12.6	51.5	<1.00	751	<1.00	518	7.12	<1.00	<1.00
HFG1-13-SSM-W	1	7	S-11797-1	<1.00	11.3	2.57	5.77	<1.00	23.4	108	<1.00	612	<1.00	504	5.51	<1.00	<1.00
hpstd	1	8	hpstd-11	47.2	9.79	<1.00	<1.00	48.4	1.36	<1.00	19.8	162	9.31	9.66	<1.00	<1.00	<1.00
HFG1-18-SSM-W	1	9	S-11802-1	<1.00	15.5	7.52	1.30	<1.00	14.7	97.9	<1.00	611	2.39	488	5.75	<1.00	<1.00
HFG1-19-SSM-W	1	10	S-11803-1	<1.00	21.6	1.46	2.40	<1.00	49.1	17.3	<1.00	1000	<1.00	505	5.77	<1.00	<1.00
HFG1-11-SSM-W	1	11	S-11795-1	1.5	16.2	2.16	15.0	<1.00	42.6	59.7	<1.00	1110	2.61	625	1.52	<1.00	<1.00
HFG1-15-SSM-W	1	12	S-11799-1	<1.00	10.7	7.73	6.51	<1.00	58.4	35.5	<1.00	630	1.19	453	9.25	<1.00	<1.00
HFG1-20-SSM-W	1	13	S-11804-1	1.31	10.3	1.62	13.0	<1.00	2.84	31.8	<1.00	833	4.87	481	9.01	<1.00	<1.00
blank	1	14	blank-1	<1.00	<1.00	<1.00	<1.00	<1.00	1.69	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
soln std	1	15	soln std-12	4.00	19.9	<1.00	<1.00	4.04	10.6	9.754	<1.00	78.6	<1.00	<1.00	52.9	<1.00	<1.00
EWG-HFG1-SSM-W	1	16	S-11805-1	<1.00	<1.00	<1.00	<1.00	<1.00	2.02	<1.00	<1.00	623	<1.00	432	<1.00	<1.00	<1.00
HFG1-06-SSM-W	1	17	S-11790-1	<1.00	15.9	1.78	8.13	<1.00	42.8	35.7	<1.00	935	4.55	477	15.2	<1.00	<1.00
HFG1-16-SSM-W	1	18	S-11800-1	1.41	8.40	3.32	19.6	<1.00	89.3	35.9	<1.00	678	4.09	441	12.0	<1.00	<1.00
HFG1-09-SSM-W	1	19	S-11793-1	<1.00	7.55	2.24	11.8	<1.00	17.1	97.0	<1.00	975	<1.00	562	5.58	<1.00	<1.00
HFG1-10-SSM-W	1	20	S-11794-1	<1.00	23.8	5.82	1.28	<1.00	44.2	38.2	<1.00	853	<1.00	510	4.18	<1.00	<1.00
hpstd	1	21	hpstd-12	47.4	9.79	<1.00	<1.00	48.3	1.89	<1.00	19.6	161	9.27	10.1	<1.00	<1.00	<1.00
HFG1-01-1-SSM-W	1	22	S-11785-1	<1.00	14.2	2.45	4.72	<1.00	85.1	136.7	<1.00	780	<1.00	614	2.28	<1.00	<1.00
HFG1-05-SSM-W	1	23	S-11789-1	<1.00	27.5	<1.00	14.4	<1.00	10.1	27.6	<1.00	1020	8.61	546	12.9	<1.00	<1.00
HFG1-08-SSM-W	1	24	S-11792-1	<1.00	15.3	1.56	20.0	<1.00	71.0	8.07	<1.00	1410	2.79	608	9.43	<1.00	<1.00
HFG1-07-SSM-W	1	25	S-11791-1	1.08	16.4	1.24	1.14	<1.00	40.8	9.83	<1.00	1030	1.71	602	3.28	<1.00	<1.00
HFG1-14-SSM-W	1	26	S-11798-1	<1.00	8.45	7.03	2.72	<1.00	5.59	12.0	<1.00	855	<1.00	453	9.78	<1.00	<1.00
soln std	1	27	soln std-13	4.01	19.9	<1.00	<1.00	4.02	10.1	9.72	<1.00	78.8	<1.00	<1.00	53.0	<1.00	<1.00
soln std	2	1	soln std-21	3.94	19.4	<1.00	<1.00	4.01	9.27	9.78	<1.00	81.4	<1.00	<1.00	52.4	<1.00	<1.00
HFG1-15-SSM-W	2	2	S-11799-2	<1.00	10.8	7.87	6.64	<1.00	59.3	35.7	<1.00	650	1.30	468	9.53	<1.00	<1.00
HFG1-20-SSM-W	2	3	S-11804-2	1.21	9.83	1.63	13.1	<1.00	2.50	31.1	<1.00	864	4.85	501	9.01	<1.00	<1.00
HFG1-08-SSM-W	2	4	S-11792-2	<1.00	15.3	1.58	20.5	<1.00	72.7	8.30	<1.00	1420	2.92	651	9.49	<1.00	<1.00
HFG1-03-SSM-W	2	5	S-11787-2	<1.00	11.4	11.1	2.20	<1.00	29.8	1.63	<1.00	994	<1.00	592	3.23	<1.00	<1.00
HFG1-05-SSM-W	2	6	S-11789-2	<1.00	26.9	<1.00	14.5	<1.00	9.70	27.4	<1.00	1060	8.56	564	12.9	<1.00	<1.00
HFG1-17-SSM-W	2	7	S-11801-2	<1.00	6.30	<1.00	4.45	<1.00	11.61	50.1	<1.00	778	<1.00	519	7.07	<1.00	<1.00
hpstd	2	8	hpstd-21	47.9	9.63	<1.00	<1.00	48.1	1.43	<1.00	20.2	159	9.37	10.2	<1.00	<1.00	<1.00

Table B-1. Measurements (mg/L) of Wash Solutions Measured by ICP-OES (continued)

Solution ID	Block	Seq	Lab ID	Al	B	Ca	Cr	Fe	K	Li	Mn	Na	P	S	Si	Zn	Zr
HFG1-16-SSM-W	2	9	S-11800-2	1.36	8.14	3.29	19.8	<1.00	90.6	35.8	<1.00	786	4.23	490	11.9	<1.00	<1.00
HFG1-01-1-SSM-W	2	10	S-11785-2	<1.00	13.9	2.47	4.76	<1.00	86.9	135	<1.00	834	<1.00	632	2.46	<1.00	<1.00
HFG1-19-SSM-W	2	11	S-11803-2	<1.00	21.7	1.52	2.43	<1.00	50.0	17.6	<1.00	1040	<1.00	512	6.01	<1.00	<1.00
HFG1-11-SSM-W	2	12	S-11795-2	1.37	15.9	2.16	15.0	<1.00	41.3	58.2	<1.00	1110	2.59	639	1.49	<1.00	<1.00
HFG1-13-SSM-W	2	13	S-11797-2	<1.00	10.9	2.60	5.73	<1.00	22.9	108	<1.00	632	<1.00	515	5.34	<1.00	<1.00
soln std	2	14	soln std-22	3.94	19.4	<1.00	<1.00	3.98	9.37	9.79	<1.00	82.2	<1.00	<1.00	52.6	<1.00	<1.00
blank	2	15	blank-2	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
HFG1-06-SSM-W	2	16	S-11790-2	<1.00	15.7	1.78	8.31	<1.00	42.4	34.9	<1.00	982	4.63	482	15.4	<1.00	<1.00
HFG1-10-SSM-W	2	17	S-11794-2	<1.00	23.4	5.73	1.26	<1.00	44.0	37.6	<1.00	923	<1.00	540	4.32	<1.00	<1.00
HFG1-02-SSM-W	2	18	S-11786-2	<1.00	10.7	4.70	2.52	<1.00	40.4	67.3	<1.00	1050	<1.00	628	5.01	<1.00	<1.00
HFG1-14-SSM-W	2	19	S-11798-2	<1.00	8.18	6.89	2.70	<1.00	4.65	12.0	<1.00	888	<1.00	467	9.70	<1.00	<1.00
HFG1-07-SSM-W	2	20	S-11791-2	1.29	16.4	1.25	1.10	<1.00	40.3	9.84	<1.00	1070	1.64	602	3.76	<1.00	<1.00
hpstd	2	21	hpstd-22	48.2	9.59	<1.00	<1.00	48.0	1.07	<1.00	20.1	160	9.08	10.3	<1.00	<1.00	<1.00
HFG1-09-SSM-W	2	22	S-11793-2	<1.00	7.27	2.36	11.9	<1.00	17.0	95.1	<1.00	1040	1.01	587	5.53	<1.00	<1.00
HFG1-12-SSM-W	2	23	S-11796-2	<1.00	10.6	1.61	1.20	<1.00	25.6	104.4	<1.00	681	<1.00	479	7.76	<1.00	<1.00
HFG1-04-SSM-W	2	24	S-11788-2	<1.00	17.9	3.83	7.70	<1.00	54.9	4.12	<1.00	765	<1.00	417	19.8	<1.00	<1.00
HFG1-18-SSM-W	2	25	S-11802-2	<1.00	15.4	7.47	1.28	<1.00	14.4	96.5	<1.00	641	2.31	497	5.75	<1.00	<1.00
EWG-HFG1-SSM-W	2	26	S-11805-2	<1.00	<1.00	<1.00	<1.00	<1.00	1.25	<1.00	<1.00	661	<1.00	439	<1.00	<1.00	<1.00
soln std	2	27	soln std-23	3.86	19.5	<1.00	<1.00	4.01	9.91	9.77	<1.00	83.8	<1.00	<1.00	52.7	<1.00	<1.00
soln std	3	1	soln std-31	4.24	19.3	<1.00	<1.00	4.03	9.49	9.68	<1.00	80.8	<1.00	<1.00	52.8	<1.00	<1.00
HFG1-08-SSM-W	3	2	S-11792-3	<1.00	15.3	1.63	20.6	<1.00	73.6	8.17	<1.00	1410	2.97	636	9.90	<1.00	<1.00
HFG1-02-SSM-W	3	3	S-11786-3	<1.00	10.8	4.83	2.58	<1.00	41.4	69.2	<1.00	1020	<1.00	620	3.90	<1.00	<1.00
HFG1-13-SSM-W	3	4	S-11797-3	<1.00	11.0	2.73	5.74	<1.00	23.1	108	<1.00	621	<1.00	510	4.37	<1.00	<1.00
HFG1-15-SSM-W	3	5	S-11799-3	<1.00	10.7	7.92	6.57	<1.00	60.3	35.8	<1.00	646	1.19	463	9.51	<1.00	<1.00
HFG1-18-SSM-W	3	6	S-11802-3	<1.00	15.3	7.49	1.28	<1.00	14.4	97.7	<1.00	624	2.32	493	6.05	<1.00	<1.00
HFG1-05-SSM-W	3	7	S-11789-3	<1.00	26.9	<1.00	14.5	<1.00	8.99	27.5	<1.00	1040	8.59	551	13.0	<1.00	<1.00
hpstd	3	8	hpstd-31	47.3	9.7	<1.00	<1.00	47.9	<1.00	<1.00	19.9	154	9.40	9.03	<1.00	<1.00	<1.00
HFG1-20-SSM-W	3	9	S-11804-3	1.50	9.99	1.65	13.1	<1.00	1.75	31.7	<1.00	860	5.03	485	9.22	<1.00	<1.00
HFG1-17-SSM-W	3	10	S-11801-3	<1.00	6.43	<1.00	4.50	<1.00	12.4	51.9	<1.00	760	<1.00	512	6.14	<1.00	<1.00
HFG1-10-SSM-W	3	11	S-11794-3	<1.00	23.5	5.79	1.26	<1.00	44.3	38.0	<1.00	888	<1.00	521	4.35	<1.00	<1.00
HFG1-16-SSM-W	3	12	S-11800-3	1.42	8.24	3.29	19.8	<1.00	91.8	36.2	<1.00	751	3.99	468	12.1	<1.00	<1.00
HFG1-11-SSM-W	3	13	S-11795-3	1.80	16.2	2.19	15.3	<1.00	42.2	58.9	<1.00	1090	2.56	631	1.72	<1.00	<1.00
blank	3	14	blank-3	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
soln std	3	15	soln std-32	4.19	19.5	<1.00	<1.00	4.01	9.61	9.74	<1.00	82.1	<1.00	<1.00	53.0	<1.00	<1.00
HFG1-04-SSM-W	3	16	S-11788-3	<1.00	17.9	3.97	7.86	<1.00	56.7	4.06	<1.00	755	<1.00	411	19.0	<1.00	<1.00

Table B-1. Measurements (mg/L) of Wash Solutions Measured by ICP-OES (continued)

Solution ID	Block	Seq	Lab ID	Al	B	Ca	Cr	Fe	K	Li	Mn	Na	P	S	Si	Zn	Zr
HFG1-01-1-SSM-W	3	17	S-11785-3	<1.00	14.2	2.63	4.83	<1.00	88.4	137	<1.00	820	<1.00	628	2.54	<1.00	<1.00
HFG1-14-SSM-W	3	18	S-11798-3	<1.00	8.17	6.89	2.73	<1.00	5.03	12.1	<1.00	878	<1.00	462	10.1	<1.00	<1.00
HFG1-03-SSM-W	3	19	S-11787-3	<1.00	11.5	11.2	2.23	<1.00	30.5	1.46	<1.00	992	<1.00	581	2.27	<1.00	<1.00
HFG1-12-SSM-W	3	20	S-11796-3	<1.00	10.7	1.58	1.21	<1.00	25.5	105	<1.00	665	<1.00	469	6.77	<1.00	<1.00
hpstd	3	21	hpstd-32	47.3	9.55	<1.00	<1.00	48.1	1.02	<1.00	20.02	157	9.22	9.86	<1.00	<1.00	<1.00
EWG-HFG1-SSM-W	3	22	S-11805-3	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	645	<1.00	437	<1.00	<1.00	<1.00
HFG1-09-SSM-W	3	23	S-11793-3	<1.00	7.31	2.19	11.7	<1.00	16.0	97.4	<1.00	1030	<1.00	580	5.66	<1.00	<1.00
HFG1-07-SSM-W	3	24	S-11791-3	1.41	16.4	1.30	1.12	<1.00	41.0	9.77	<1.00	1070	1.70	597	4.01	<1.00	<1.00
HFG1-19-SSM-W	3	25	S-11803-3	<1.00	21.6	1.53	2.40	<1.00	50.4	17.4	<1.00	1040	<1.00	504	5.88	<1.00	<1.00
HFG1-06-SSM-W	3	26	S-11790-3	<1.00	15.7	1.51	8.55	<1.00	43.5	34.7	<1.00	984	4.57	473	14.6	<1.00	<1.00
soln std	3	27	soln std-33	4.13	19.3	<1.00	<1.00	4.00	9.48	9.69	<1.00	82.3	<1.00	<1.00	52.8	<1.00	<1.00

Table B-2. Measurements (mg/L) of Wash Solutions Measured by IC

Solution ID	Block	Seq	Lab ID	Fluoride	Phosphate	Sulfate
ckstd IC-167	1	1	ckstd IC-167	9.69	10.0	9.74
HFG1-20-SSM-W	1	2	S-11804-1	125	13.4	1480
HFG1-19-SSM-W	1	3	S-11803-1	257	<10.0	1520
HFG1-07-SSM-W	1	4	S-11791-1	161	<10.0	1810
HFG1-10-SSM-W	1	5	S-11794-1	172	<10.0	1580
HFG1-09-SSM-W	1	6	S-11793-1	396	<10.0	1710
BLANK	1	7	BLANK-1A	<10.0	<10.0	<10.0
HFG1-02-SSM-W	1	8	S-11786-1	286	<10.0	1850
HFG1-18-SSM-W	1	9	S-11802-1	150	<10.0	1490
HFG1-13-SSM-W	1	10	S-11797-1	157	<10.0	1550
HFG1-04-SSM-W	1	11	S-11788-1	83.4	<10.0	1230
HFG1-08-SSM-W	1	12	S-11792-1	440	<10.0	1880
HFG1-15-SSM-W	1	13	S-11799-1	55.6	<10.0	1400
HFG1-05-SSM-W	1	14	S-11789-1	166	23.5	1650
HFG1-03-SSM-W	1	15	S-11787-1	115	<10.0	1760
EWG-HFG1-SSM-W	1	16	S-11805-1	<10.0	<10.0	1320
HFG1-14-SSM-W	1	17	S-11798-1	159	<10.0	1390
HFG1-12-SSM-W	1	18	S-11796-1	222	<10.0	1410
HFG1-17-SSM-W	1	19	S-11801-1	96.1	<10.0	1560
HFG1-06-SSM-W	1	20	S-11790-1	258	12.1	1420
HFG1-01-1-SSM-W	1	21	S-11785-1	283	<10.0	1860
HFG1-16-SSM-W	1	22	S-11800-1	81.4	<10.0	1420
HFG1-11-SSM-W	1	23	S-11795-1	323	<10.0	1890
ckstd IC-167	1	24	ckstd IC-167	9.73	9.91	9.81
ckstd IC-167	2	1	ckstd IC-167	9.72	9.96	9.81
HFG1-03-SSM-W	2	2	S-11787-2	115	<10.0	1760
HFG1-09-SSM-W	2	3	S-11793-2	397	<10.0	1720
HFG1-19-SSM-W	2	4	S-11803-2	258	<10.0	1530
HFG1-11-SSM-W	2	5	S-11795-2	323	<10.0	1890
HFG1-13-SSM-W	2	6	S-11797-2	158	<10.0	1560
HFG1-20-SSM-W	2	7	S-11804-2	126	14.2	1490
HFG1-02-SSM-W	2	8	S-11786-2	287	<10.0	1870
HFG1-01-1-SSM-W	2	9	S-11785-2	284	<10.0	1870
HFG1-16-SSM-W	2	10	S-11800-2	82.0	<10.0	1430
BLANK	2	11	BLANK-2A	<10.0	<10.0	<10.0
HFG1-17-SSM-W	2	12	S-11801-2	98.2	<10.0	1620
HFG1-12-SSM-W	2	13	S-11796-2	227	<10.0	1480
EWG-HFG1-SSM-W	2	14	S-11805-2	<10.0	<10.0	1390
HFG1-15-SSM-W	2	15	S-11799-2	58.2	<10.0	1470
HFG1-14-SSM-W	2	16	S-11798-2	163	<10.0	1470
HFG1-05-SSM-W	2	17	S-11789-2	172	26.3	1740
HFG1-10-SSM-W	2	18	S-11794-2	176	<10.0	1660
HFG1-07-SSM-W	2	19	S-11791-2	165	<10.0	1900
HFG1-18-SSM-W	2	20	S-11802-2	154	<10.0	1570
HFG1-08-SSM-W	2	21	S-11792-2	458	<10.0	1980
HFG1-04-SSM-W	2	22	S-11788-2	87.1	<10.0	1300
HFG1-06-SSM-W	2	23	S-11790-2	264	12.7	1490
ckstd IC-167	2	24	ckstd IC-167	10.0	10.3	10.3
ckstd IC-167	3	1	ckstd IC-167	9.76	10.1	9.90
HFG1-17-SSM-W	3	2	S-11801-3	96.4	<10.0	1570

Table B-2. Measurements (mg/L) of Wash Solutions Measured by IC (continued)

Solution ID	Block	Seq	Lab ID	Fluoride	Phosphate	Sulfate
HFG1-06-SSM-W	3	3	S-11790-3	256	12.0	1420
HFG1-03-SSM-W	3	4	S-11787-3	115	<10.0	1770
HFG1-12-SSM-W	3	5	S-11796-3	220	<10.0	1410
HFG1-18-SSM-W	3	6	S-11802-3	149	<10.0	1500
HFG1-10-SSM-W	3	7	S-11794-3	170	<10.0	1580
BLANK	3	8	BLANK-3A	<10.0	<10.0	<10.0
HFG1-01-1-SSM-W	3	9	S-11785-3	282	<10.0	1870
HFG1-05-SSM-W	3	10	S-11789-3	166	24.8	1670
HFG1-13-SSM-W	3	11	S-11797-3	156	<10.0	1560
HFG1-14-SSM-W	3	12	S-11798-3	158	<10.0	1400
HFG1-09-SSM-W	3	13	S-11793-3	394	<10.0	1730
HFG1-11-SSM-W	3	14	S-11795-3	322	<10.0	1900
HFG1-02-SSM-W	3	15	S-11786-3	285	<10.0	1870
HFG1-19-SSM-W	3	16	S-11803-3	257	<10.0	1530
HFG1-04-SSM-W	3	17	S-11788-3	83.7	<10.0	1240
HFG1-15-SSM-W	3	18	S-11799-3	56.1	<10.0	1410
HFG1-07-SSM-W	3	19	S-11791-3	160	<10.0	1820
HFG1-20-SSM-W	3	20	S-11804-3	125	14.2	1500
EWG-HFG1-SSM-W	3	21	S-11805-3	<10.0	<10.0	1330
HFG1-16-SSM-W	3	22	S-11800-3	82.0	<10.0	1440
HFG1-08-SSM-W	3	23	S-11792-3	441	<10.0	1890
ckstd IC-167	3	24	ckstd IC-167	9.69	9.96	9.88

Table B-3. Results for Standards and Blanks Utilized During the Measurement of the Wash Solutions

Solution Identifier	Instrument	Analyte	Reference Value (mg/L)	Mean Measurement (mg/L)
BLANK	IC	F	0	<10.0
BLANK	IC	PO_4	0	<10.0
BLANK	IC	SO_4	0	<10.0
ckstd IC-167	IC	F	10	9.77
ckstd IC-167	IC	PO_4	10	10
ckstd IC-167	IC	SO_4	10	9.91
blank	ICP-OES	Al	0	<1.00
blank	ICP-OES	B	0	<1.00
blank	ICP-OES	Ca	0	<1.00
blank	ICP-OES	Cr	0	<1.00
blank	ICP-OES	Fe	0	<1.00
blank	ICP-OES	K	0	<1.23
blank	ICP-OES	Li	0	<1.00
blank	ICP-OES	Mn	0	<1.00
blank	ICP-OES	Na	0	<1.00
blank	ICP-OES	P	0	<1.00
blank	ICP-OES	S	0	<1.00
blank	ICP-OES	Si	0	<1.00
blank	ICP-OES	Zn	0	<1.00
blank	ICP-OES	Zr	0	<1.00
hpstd	ICP-OES	Al	50	47.6
hpstd	ICP-OES	B	10	9.68
hpstd	ICP-OES	Ca	0	<1.00
hpstd	ICP-OES	Cr	0	<1.00
hpstd	ICP-OES	Fe	50	48.1
hpstd	ICP-OES	K	0	<1.30
hpstd	ICP-OES	Li	0	<1.00
hpstd	ICP-OES	Mn	20	19.9
hpstd	ICP-OES	Na	150	159
hpstd	ICP-OES	P	10	9.28
hpstd	ICP-OES	S	10	9.86
hpstd	ICP-OES	Si	0	<1.00
hpstd	ICP-OES	Zn	0	<1.00
hpstd	ICP-OES	Zr	0	<1.00
soln std	ICP-OES	Al	4	4.01
soln std	ICP-OES	B	20	19.5
soln std	ICP-OES	Ca	0	<1.00
soln std	ICP-OES	Cr	0	<1.00
soln std	ICP-OES	Fe	4	4.02
soln std	ICP-OES	K	10	9.74
soln std	ICP-OES	Li	10	9.71
soln std	ICP-OES	Mn	0	<1.00
soln std	ICP-OES	Na	81	81.1
soln std	ICP-OES	P	0	<1.00
soln std	ICP-OES	S	0	<1.00
soln std	ICP-OES	Si	50	52.7
soln std	ICP-OES	Zn	0	<1.00
soln std	ICP-OES	Zr	0	<1.00

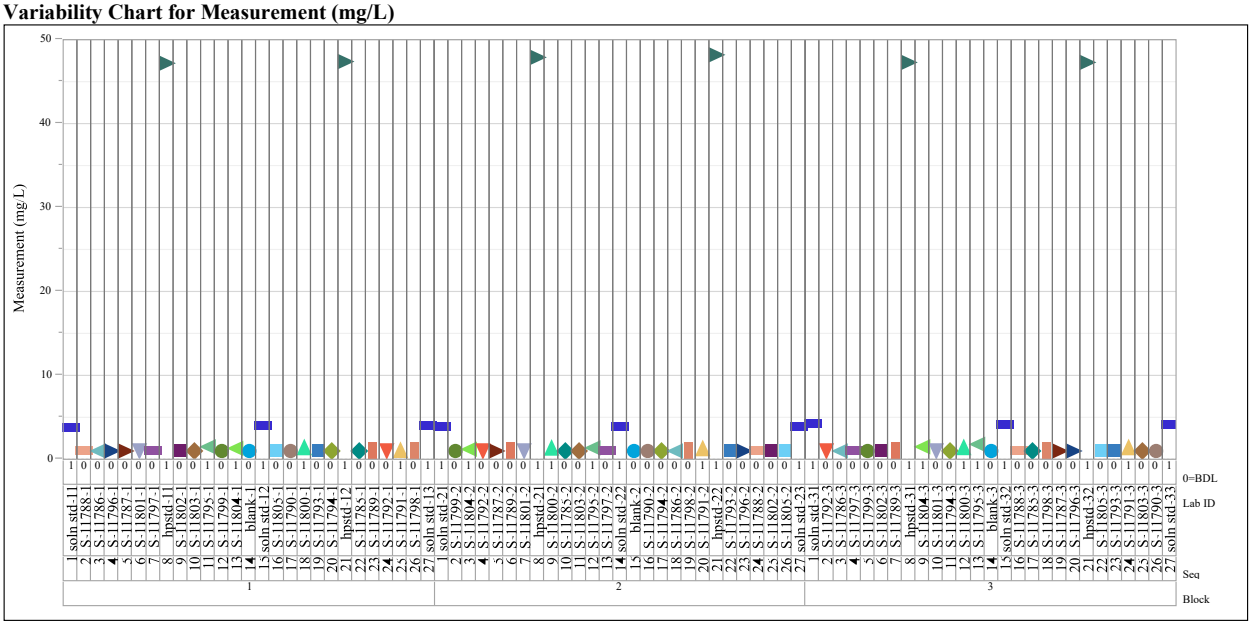
Table B-4. Average Measurements of Wash Solutions

Mean Measurement (mg/L)																				
		IC			ICP-OES															
SRNL ID	**PNNL Solution ID**	**F^-**	**PO_4**	**SO_4**	**Al**	**B**	**Ca**	**Cr**	**Fe**	**K**	**Li**	**Mn**	**Na**	**P**	**PO_4***	**S**	**SO_4***	**Si**	**Zn**	**Zr**
S-11805	EWG-HFG1-SSM-W	<10	<10	1350	<1	<1	<1	<1	<1	<1.42	<1	<1	643	<1	<3.07	436	1310	<1	<1	<1
S-11785	HFG1-01-1-SSM-W	283	<10	1870	<1	14.1	2.52	4.77	<1	86.8	136	<1	811	<1	<3.07	625	1870	2.43	<1	<1
S-11786	HFG1-02-SSM-W	286	<10	1860	<1	10.9	4.77	2.56	<1	41	68.6	<1	1030	<1	<3.07	622	1860	4.64	<1	<1
S-11787	HFG1-03-SSM-W	115	<10	1760	<1	11.6	11.2	2.21	<1	30	1.52	<1	988	<1	<3.07	584	1750	2.93	<1	<1
S-11788	HFG1-04-SSM-W	84.7	<10	1260	<1	17.9	3.88	7.81	<1	55.7	4.06	<1	751	<1	<3.07	412	1230	19.5	<1	<1
S-11789	HFG1-05-SSM-W	168	24.9	1690	<1	27.1	<1	14.5	<1	9.6	27.5	<1	1040	8.59	26.3	554	1660	12.9	<1	<1
S-11790	HFG1-06-SSM-W	259	12.3	1440	<1	15.8	1.69	8.33	<1	42.9	35.1	<1	967	4.58	14.1	477	1430	15.1	<1	<1
S-11791	HFG1-07-SSM-W	162	<10	1840	1.26	16.4	1.26	1.12	<1	40.7	9.81	<1	1060	1.68	5.16	600	1800	3.68	<1	<1
S-11792	HFG1-08-SSM-W	446	<10	1920	<1	15.3	1.59	20.4	<1	72.4	8.18	<1	1410	2.89	8.87	632	1890	9.61	<1	<1
S-11793	HFG1-09-SSM-W	396	<10	1720	<1	7.38	2.26	11.8	<1	16.7	96.5	<1	1020	<1	<3.07	576	1730	5.59	<1	<1
S-11794	HFG1-10-SSM-W	173	<10	1610	<1	23.6	5.78	1.27	<1	44.2	37.9	<1	888	<1	<3.07	524	1570	4.28	<1	<1
S-11795	HFG1-11-SSM-W	323	<10	1890	1.56	16.1	2.17	15.1	<1	42	58.9	<1	1100	2.59	7.93	632	1890	1.58	<1	<1
S-11796	HFG1-12-SSM-W	223	<10	1430	<1	10.8	1.57	1.22	<1	25.5	105	<1	666	<1	<3.07	474	1420	7.36	<1	<1
S-11797	HFG1-13-SSM-W	157	<10	1560	<1	11.1	2.63	5.75	<1	23.1	108	<1	622	<1	<3.07	510	1530	5.07	<1	<1
S-11798	HFG1-14-SSM-W	160	<10	1420	<1	8.27	6.94	2.72	<1	5.09	12	<1	874	<1	<3.07	461	1380	9.86	<1	<1
S-11799	HFG1-15-SSM-W	56.6	<10	1430	<1	10.7	7.84	6.57	<1	59.3	35.7	<1	642	1.23	3.76	461	1380	9.43	<1	<1
S-11800	HFG1-16-SSM-W	81.8	<10	1430	1.4	8.26	3.3	19.7	<1	90.6	36	<1	738	4.1	12.6	466	1400	12	<1	<1
S-11801	HFG1-17-SSM-W	96.9	<10	1580	<1	6.44	<1	4.49	<1	12.2	51.2	<1	763	<1	<3.07	516	1550	6.78	<1	<1
S-11802	HFG1-18-SSM-W	151	<10	1520	<1	15.4	7.49	1.29	<1	14.5	97.4	<1	625	2.34	7.17	493	1480	5.85	<1	<1
S-11803	HFG1-19-SSM-W	257	<10	1530	<1	21.6	1.5	2.41	<1	49.8	17.4	<1	1030	<1	<3.07	507	1520	5.89	<1	<1
S-11804	HFG1-20-SSM-W	125	13.9	1490	1.34	10	1.63	13.1	<1	2.36	31.5	<1	852	4.92	15.1	489	1460	9.08	<1	<1

* ICP-OES SO_4 and PO_4 values were calculated from the ICP-OES S and P values.

Exhibit B-1. Measurements of Wash Solutions in Analytical Sequence

Analyte=Al (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)



Analyte=B (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)

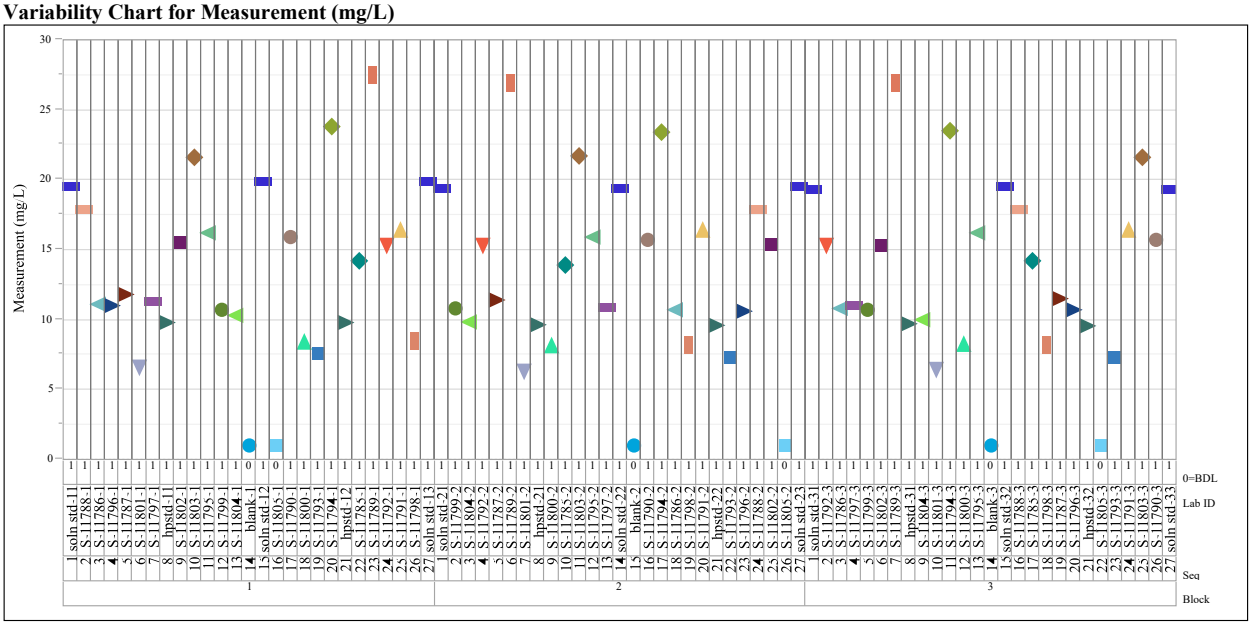
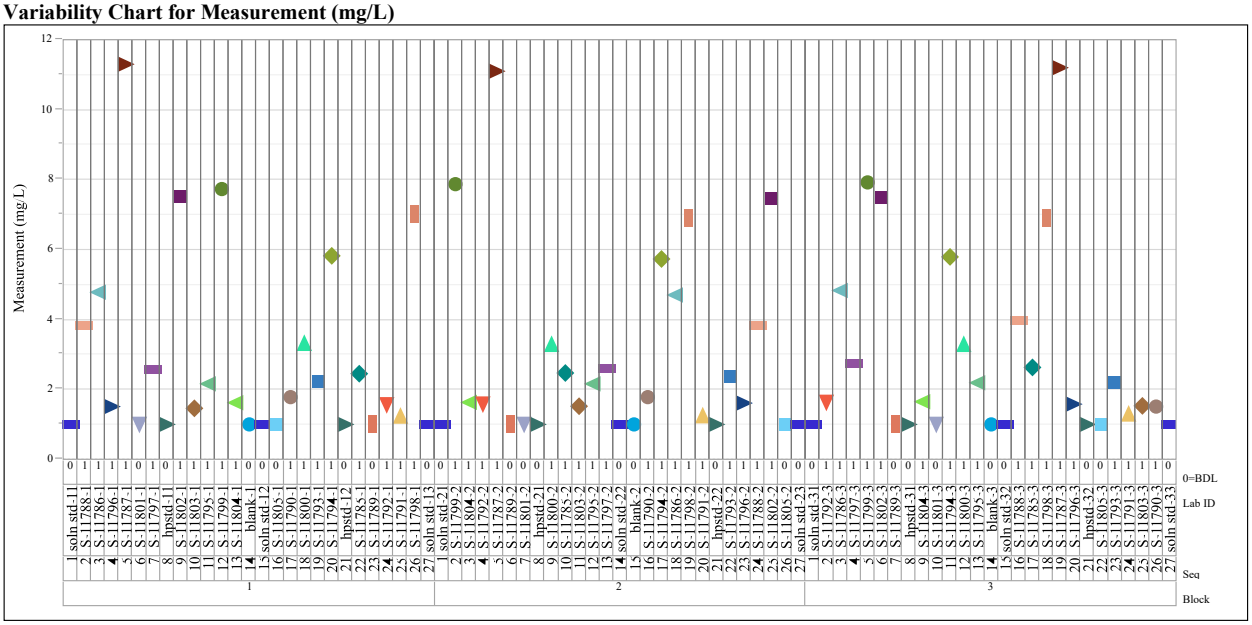


Exhibit B-1. Measurements of Wash Solutions in Analytical Sequence (continued)

Analyte=Ca (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)



Analyte=Cr (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)

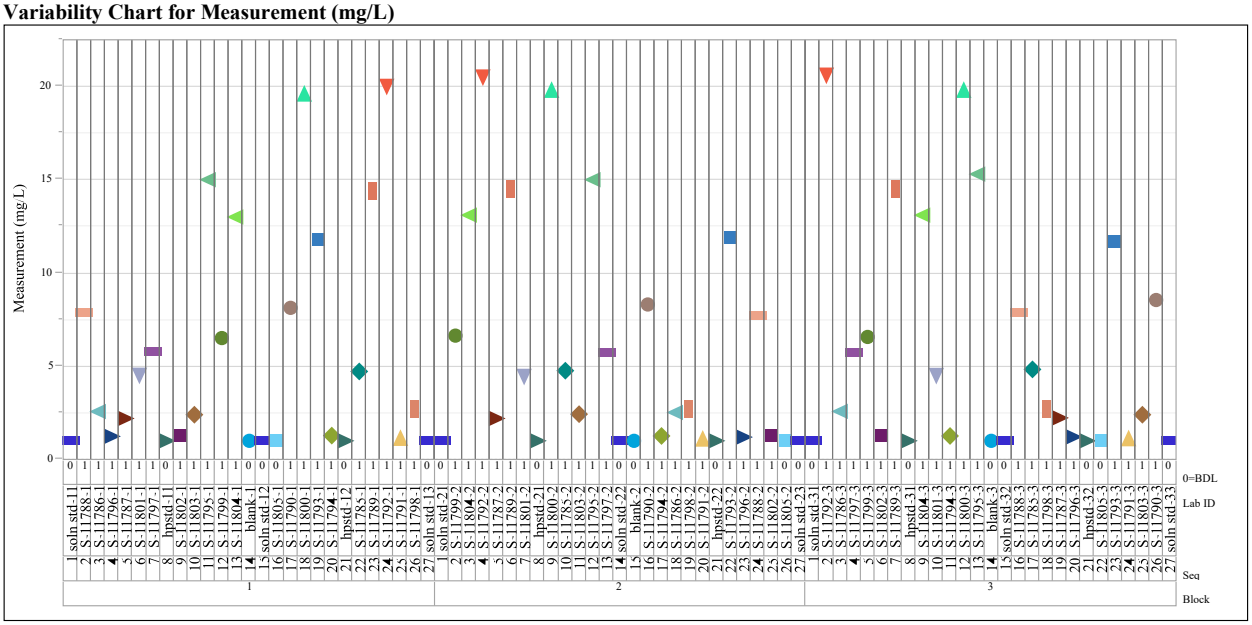
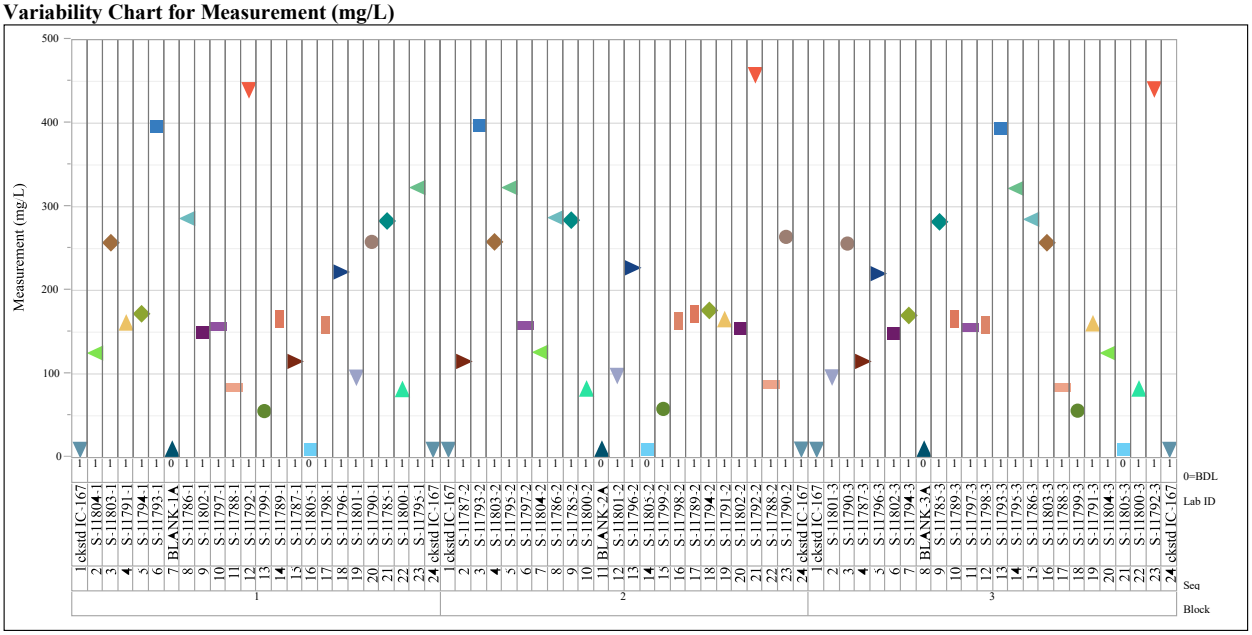


Exhibit B-1. Measurements of Wash Solutions in Analytical Sequence (continued)

Analyte=F (mg/L), Analysis=IC
Variability Chart for Measurement (mg/L)



Analyte=Fe (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)

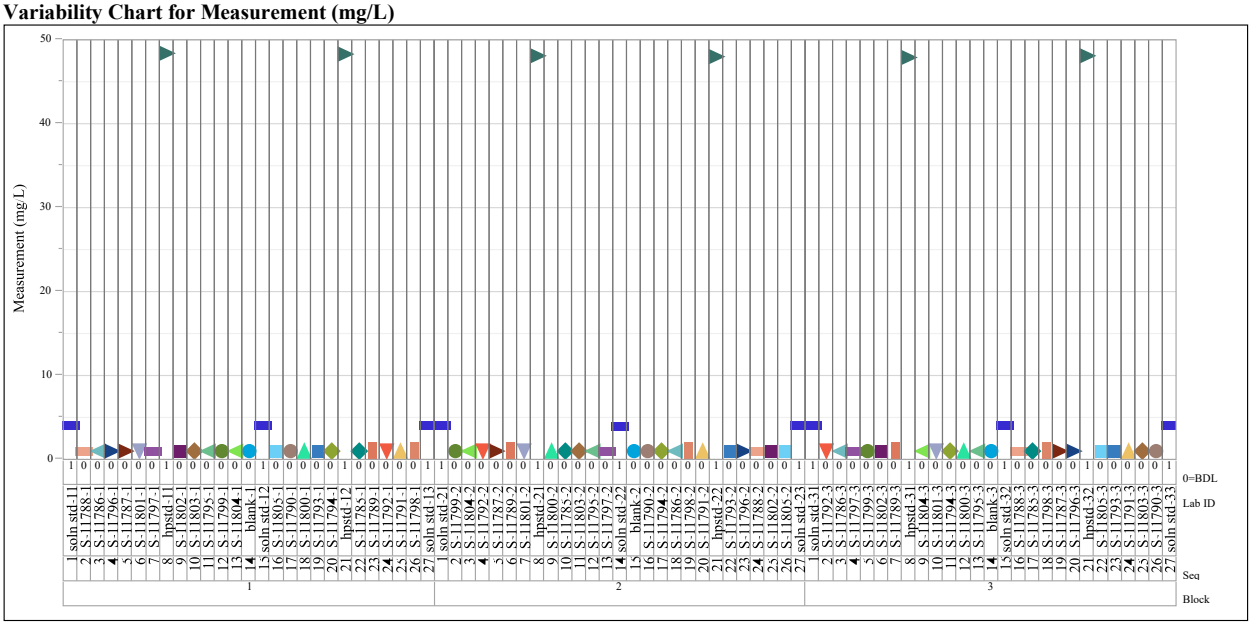
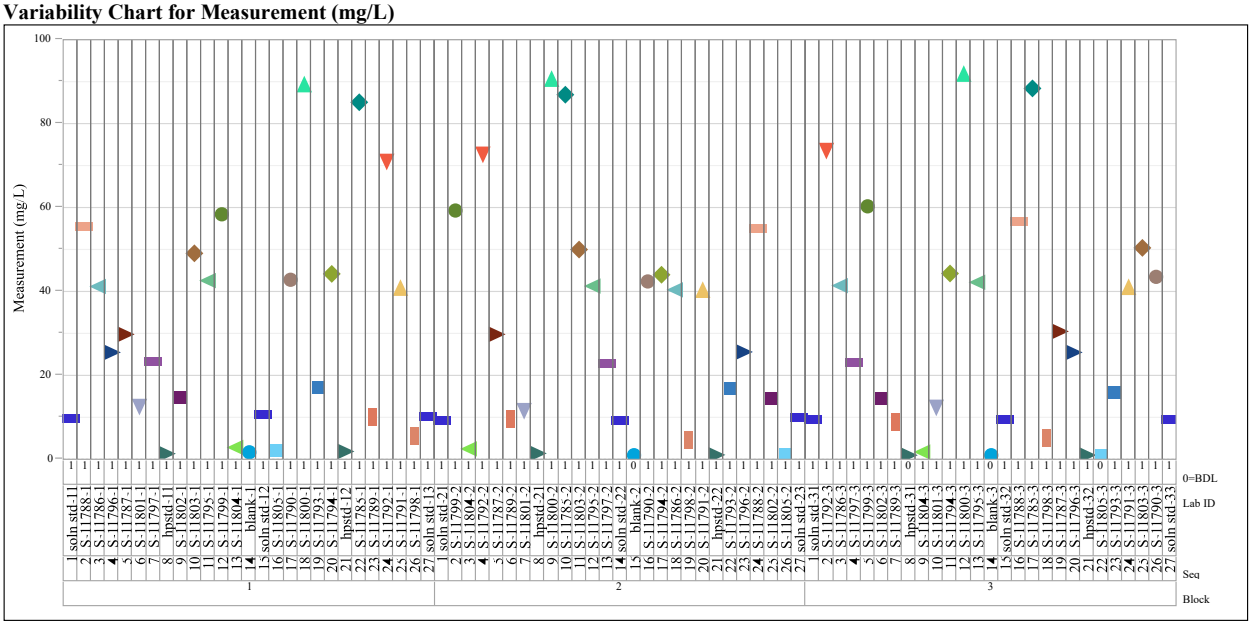


Exhibit B-1. Measurements of Wash Solutions in Analytical Sequence (continued)

Analyte=K (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)



Analyte=Li (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)

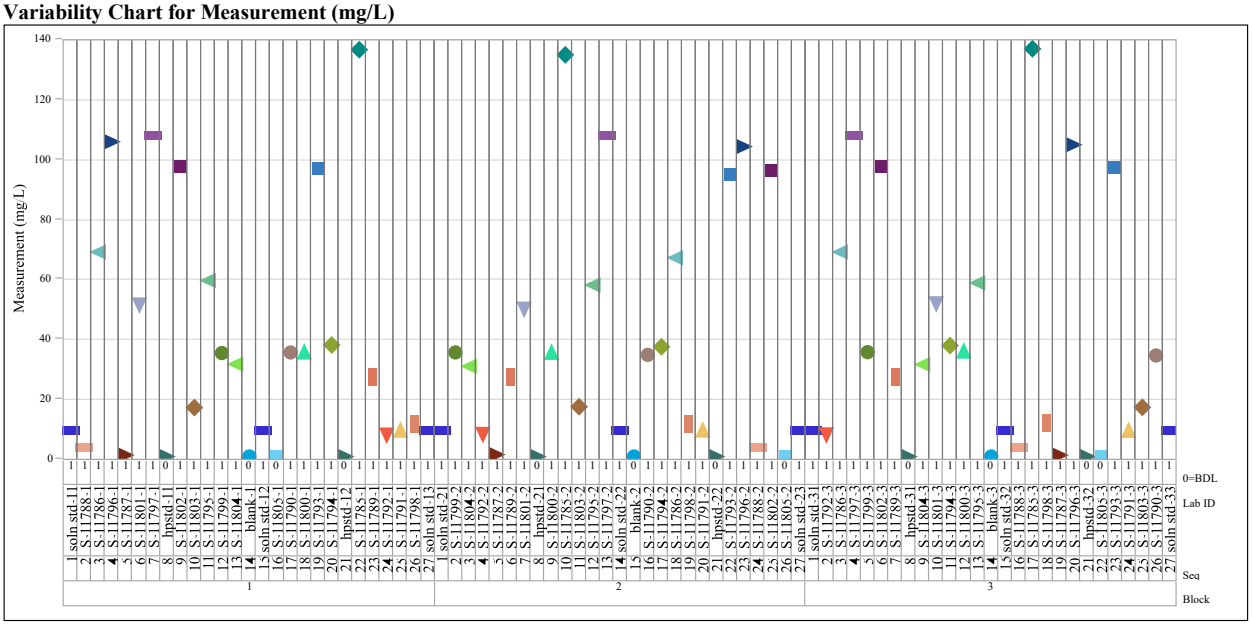
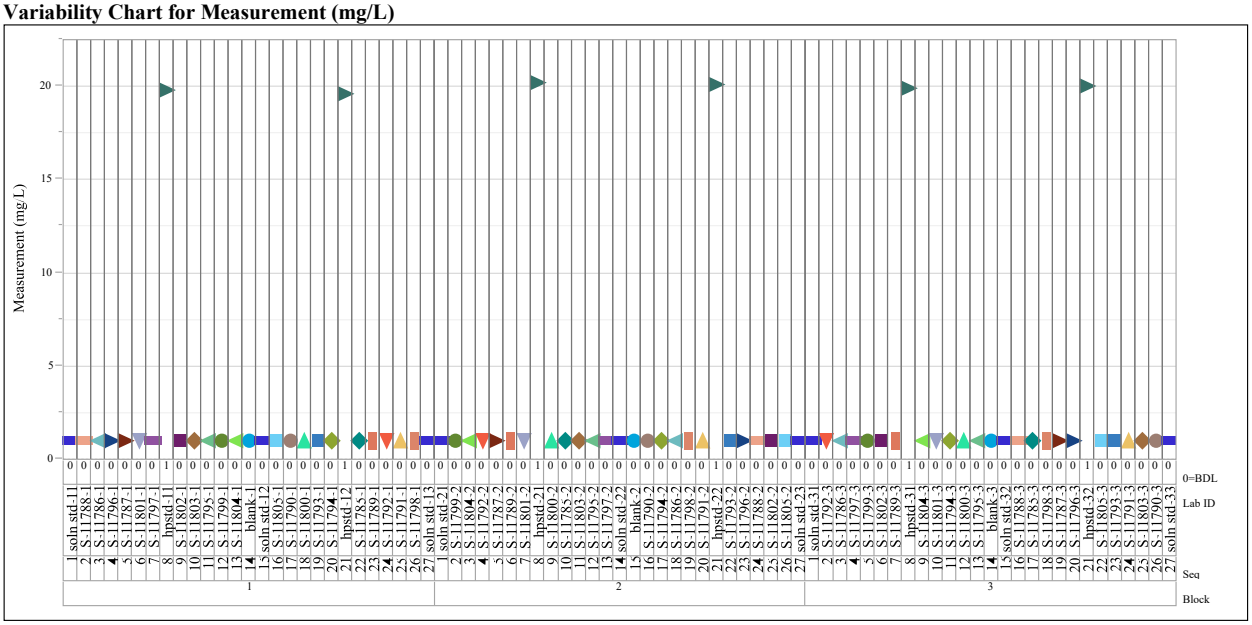


Exhibit B-1. Measurements of Wash Solutions in Analytical Sequence (continued)

Analyte=Mg (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)



Analyte=Na (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)

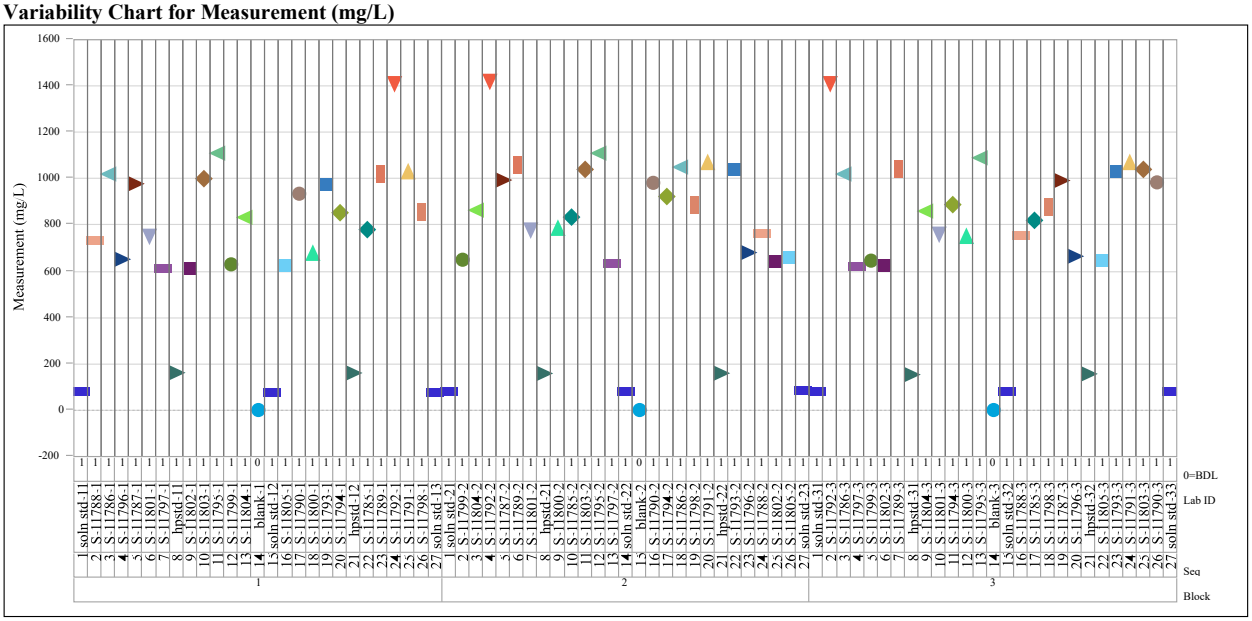
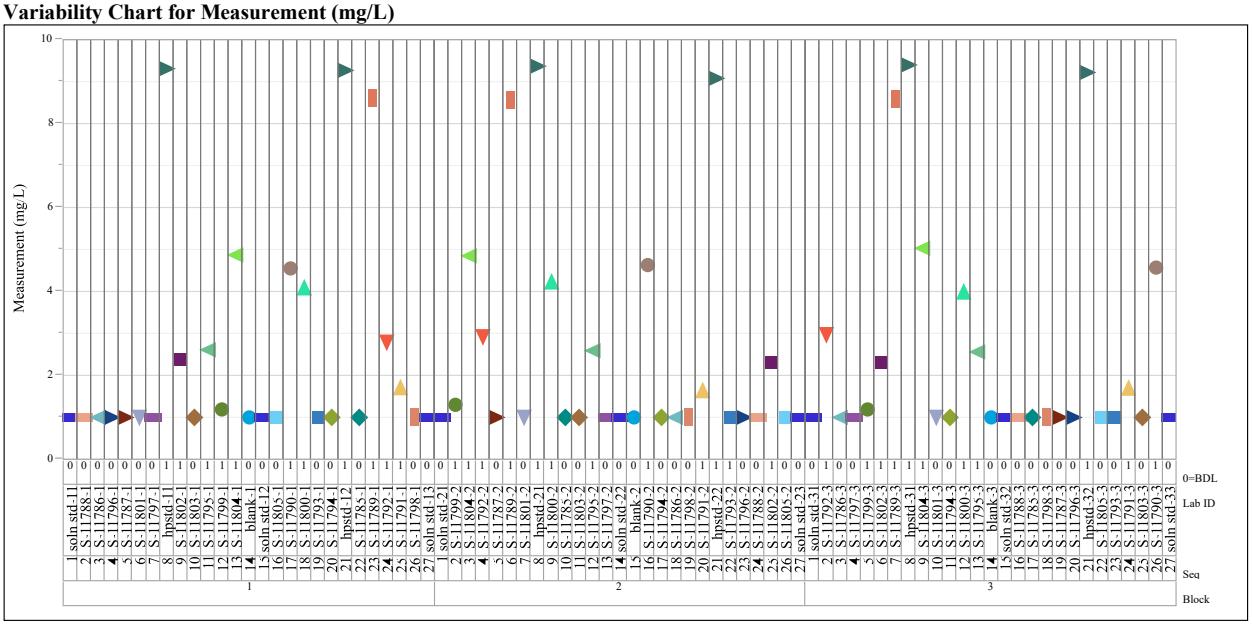


Exhibit B-1. Measurements of Wash Solutions in Analytical Sequence (continued)

Analyte=P (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)



Analyte=PO4 (mg/L), Analysis=IC
Variability Chart for Measurement (mg/L)

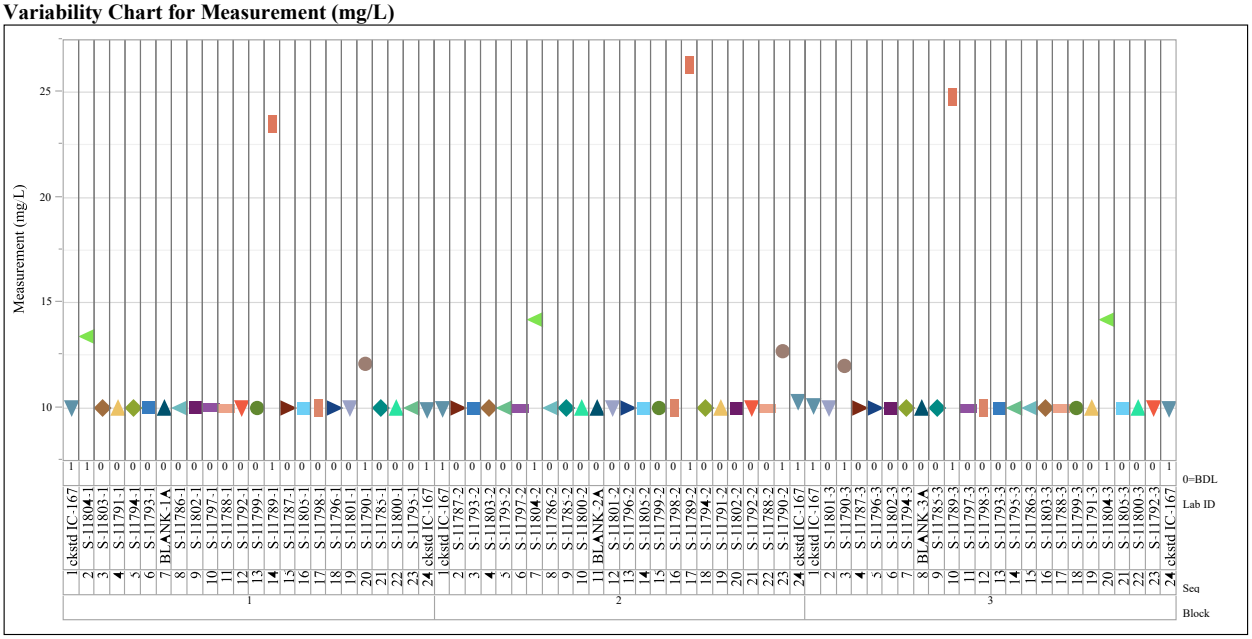
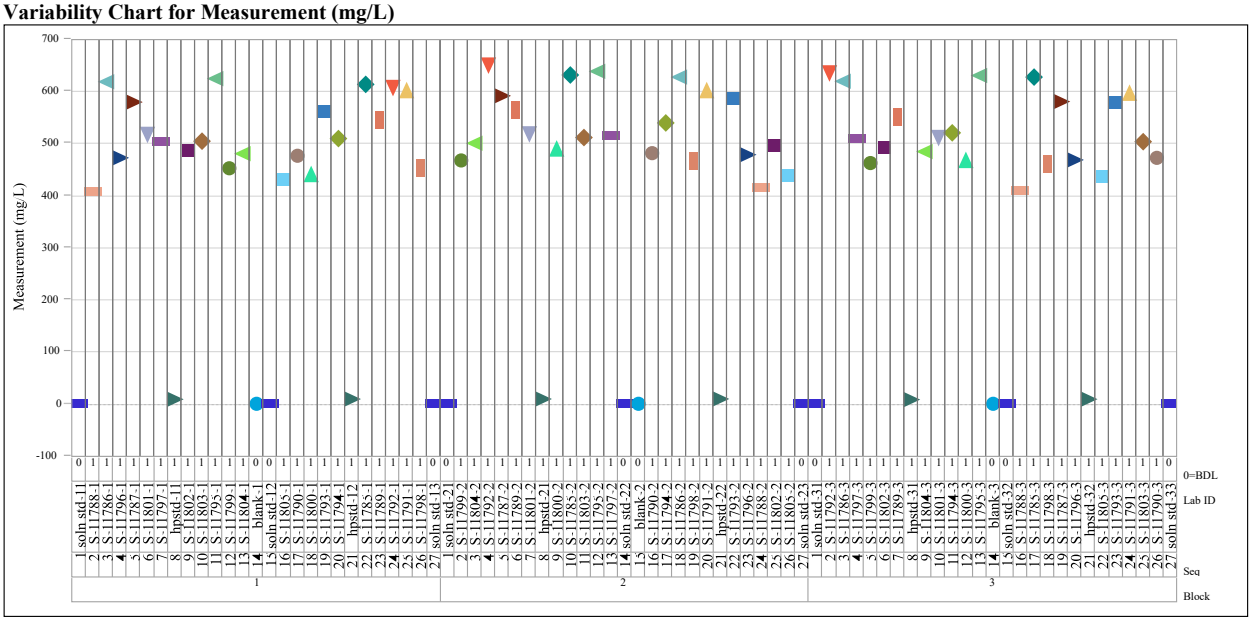


Exhibit B-1. Measurements of Wash Solutions in Analytical Sequence (continued)

Analyte=S (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)



Analyte=Si (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)

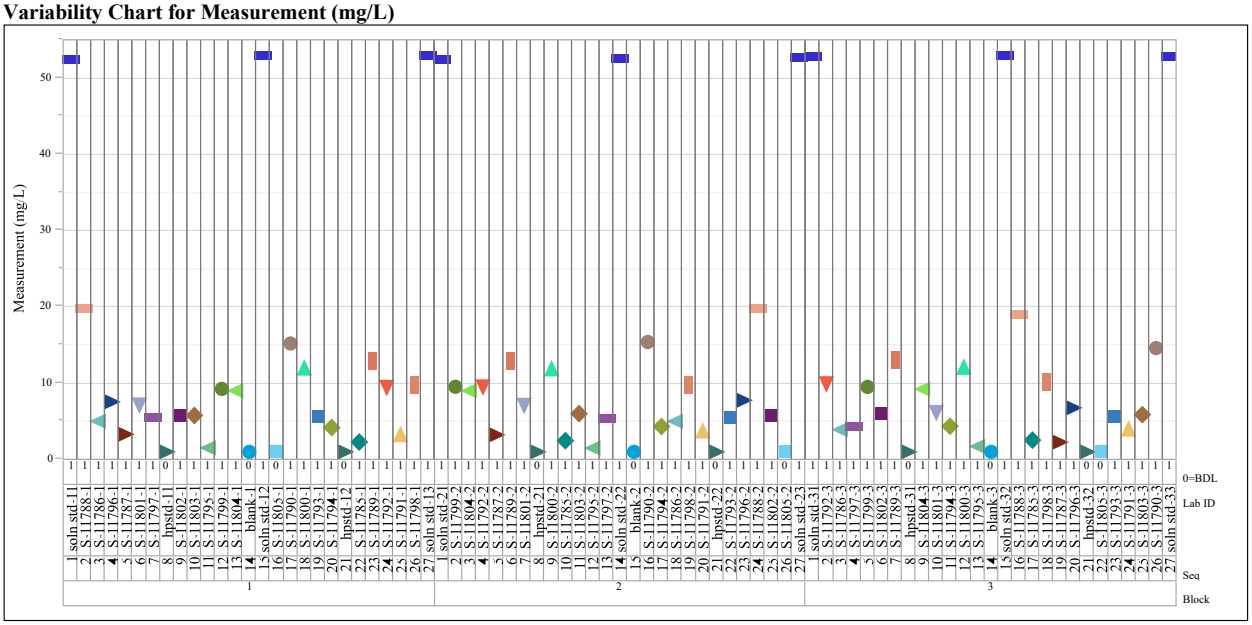
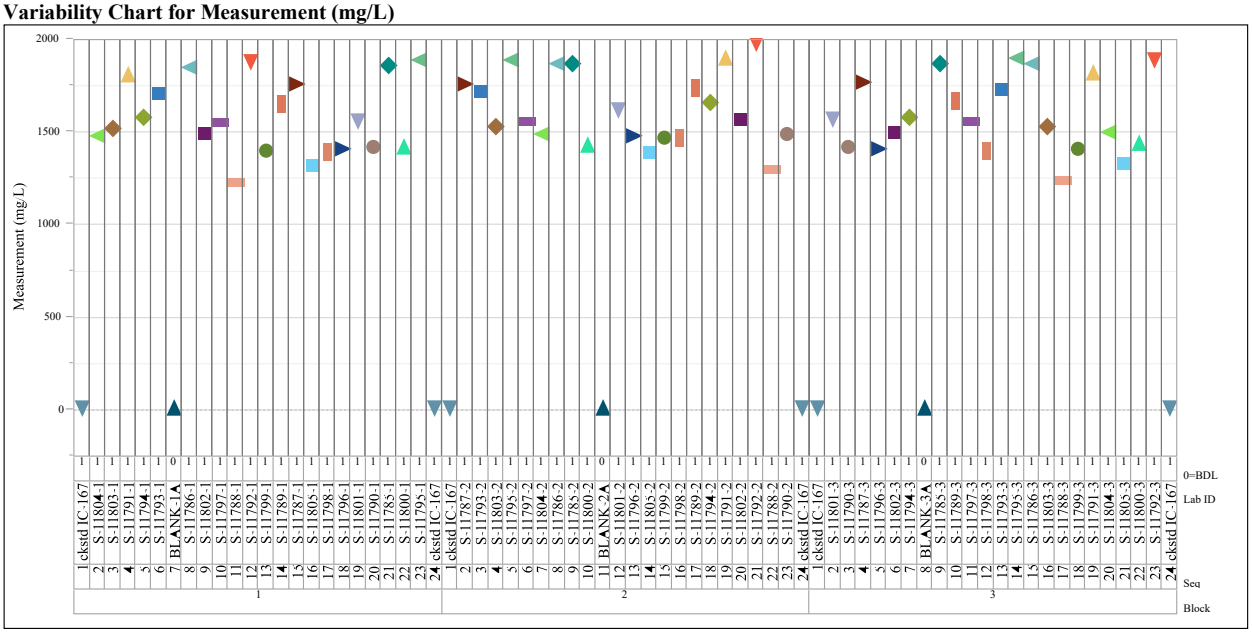


Exhibit B-1. Measurements of Wash Solutions in Analytical Sequence (continued)

Analyte=SO4 (mg/L), Analysis=IC
Variability Chart for Measurement (mg/L)



Analyte=Zn (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)

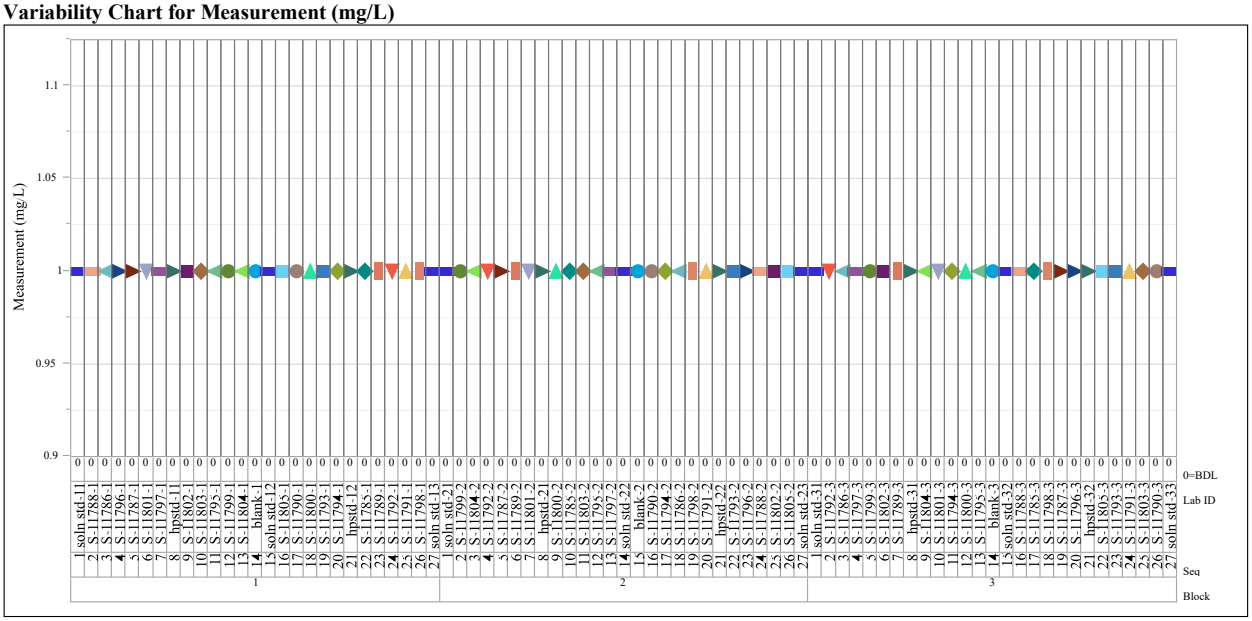


Exhibit B-1. Measurements of Wash Solutions in Analytical Sequence (continued)

Analyte=Zr (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)

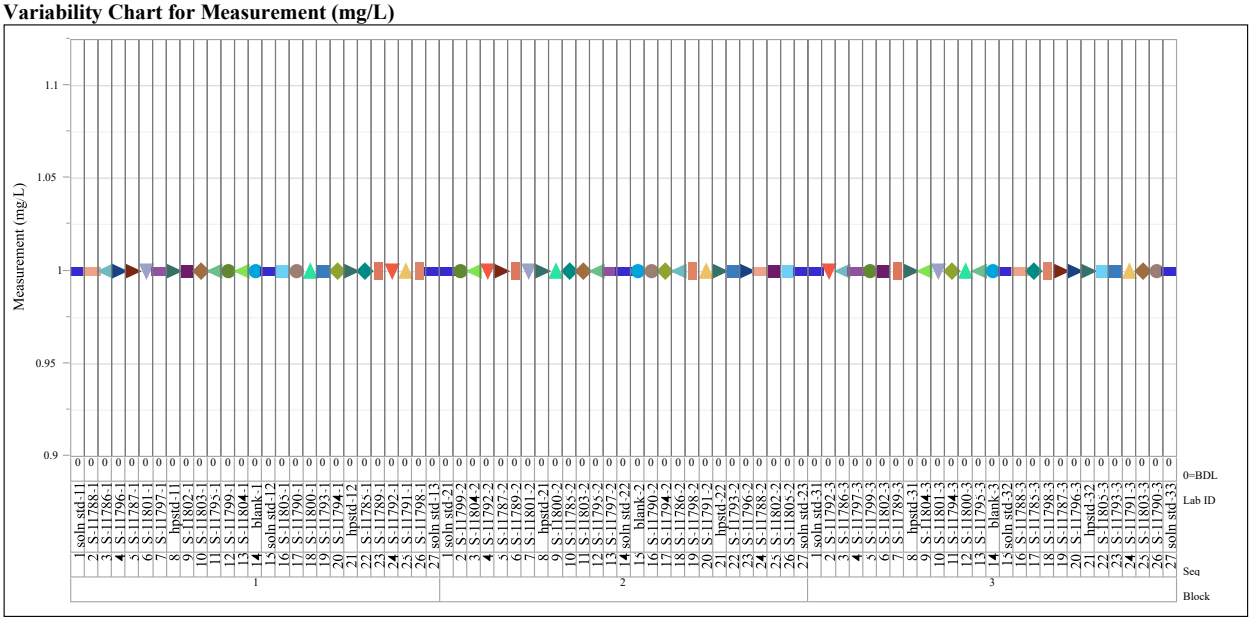
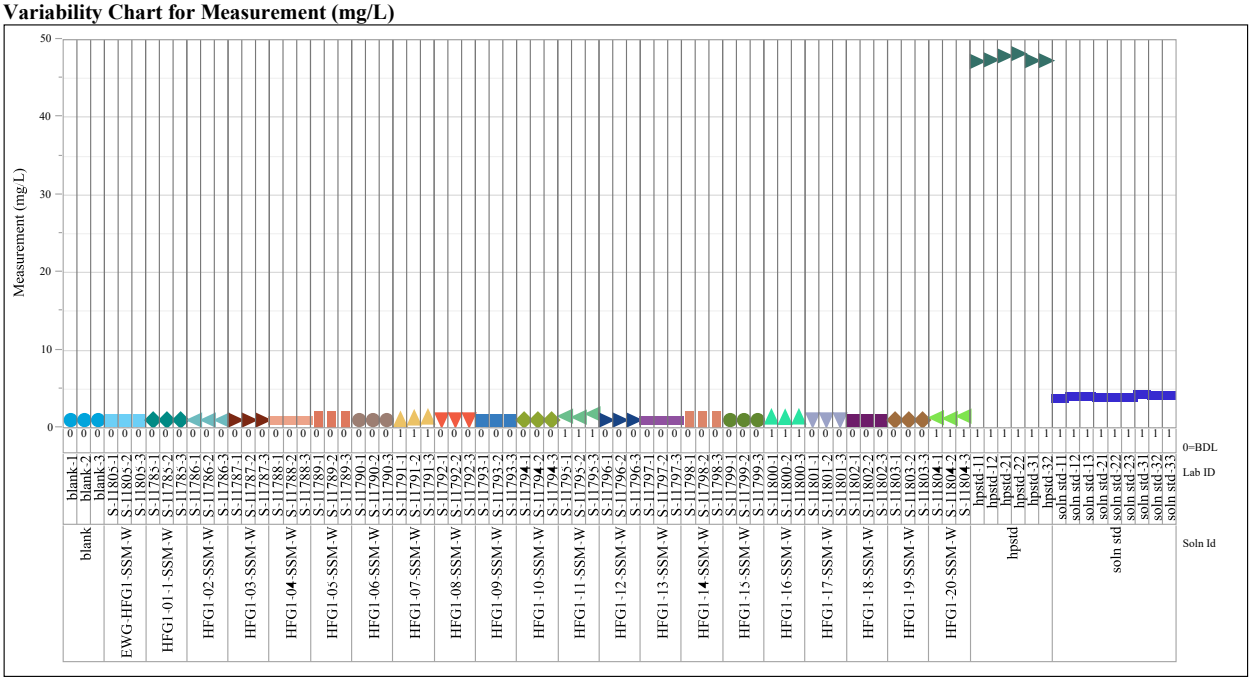
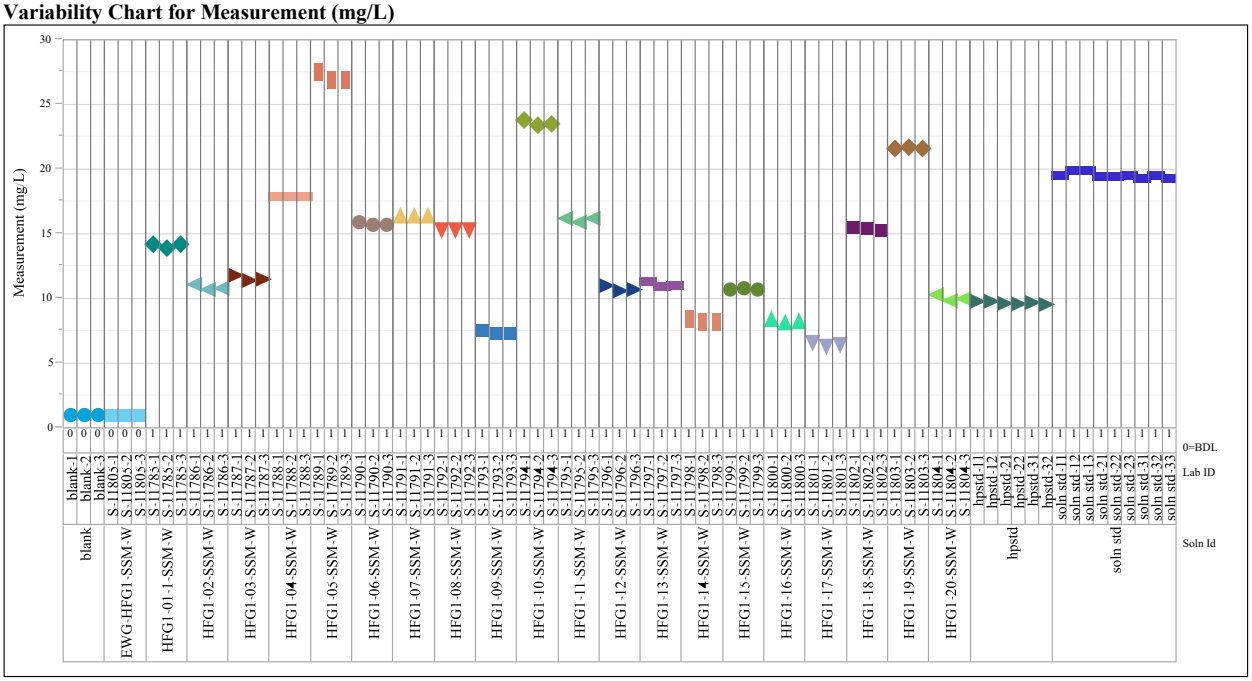


Exhibit B-2. Measurements of Wash Solutions by Analyte Grouped by Solution ID

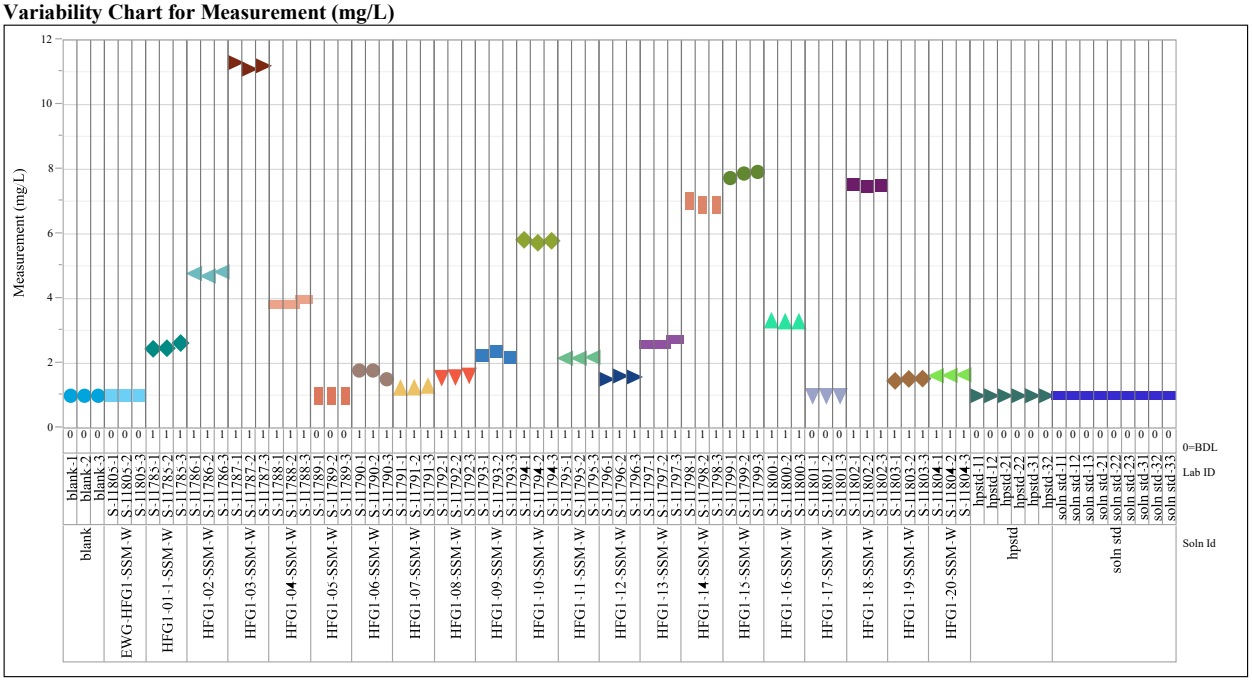
Analyte=Al (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)



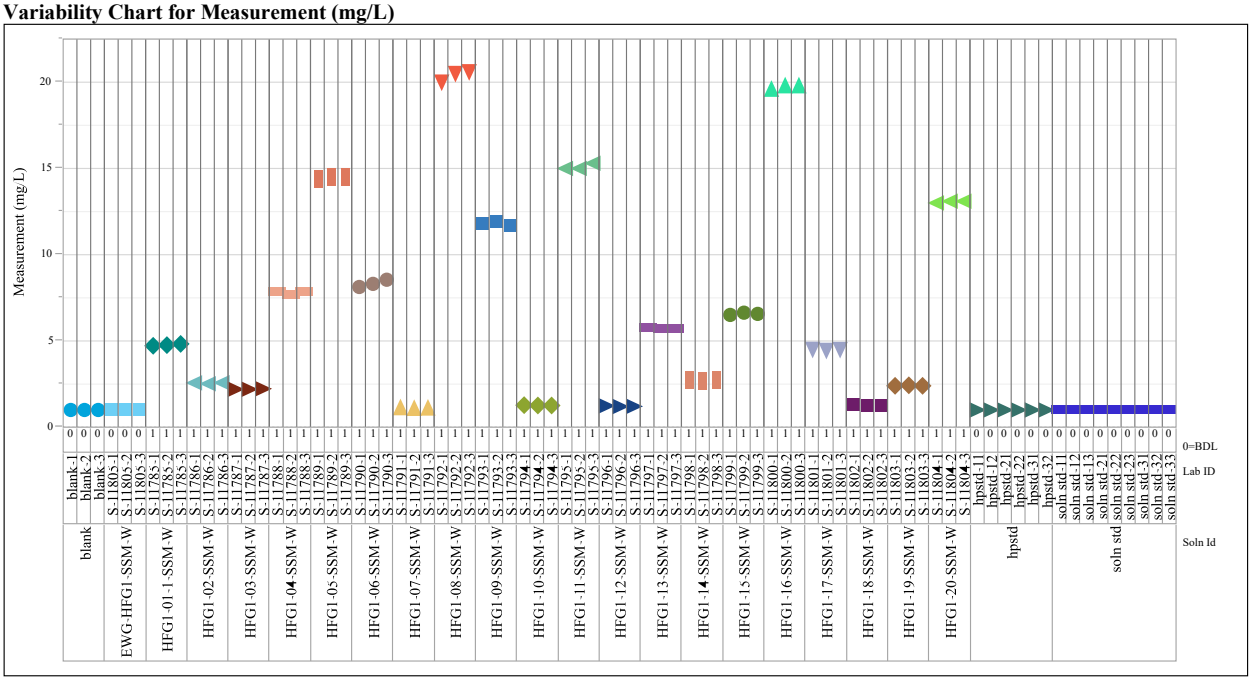
Analyte=B (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)



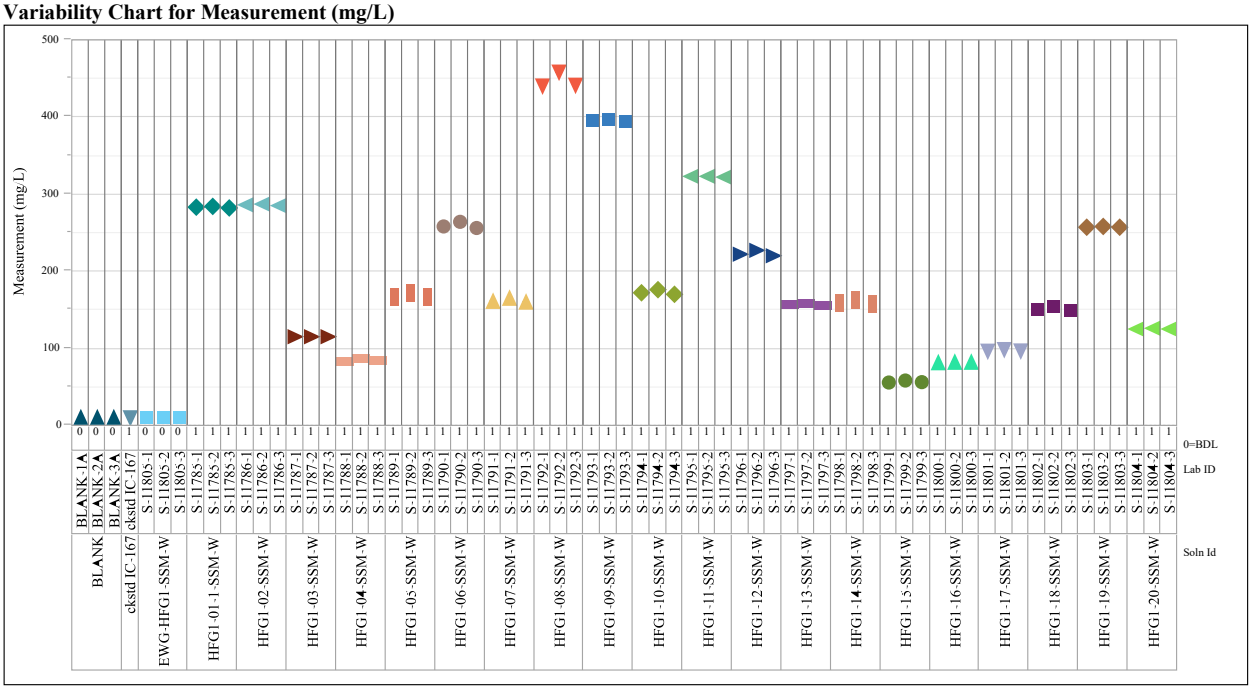
Analyte=Ca (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)



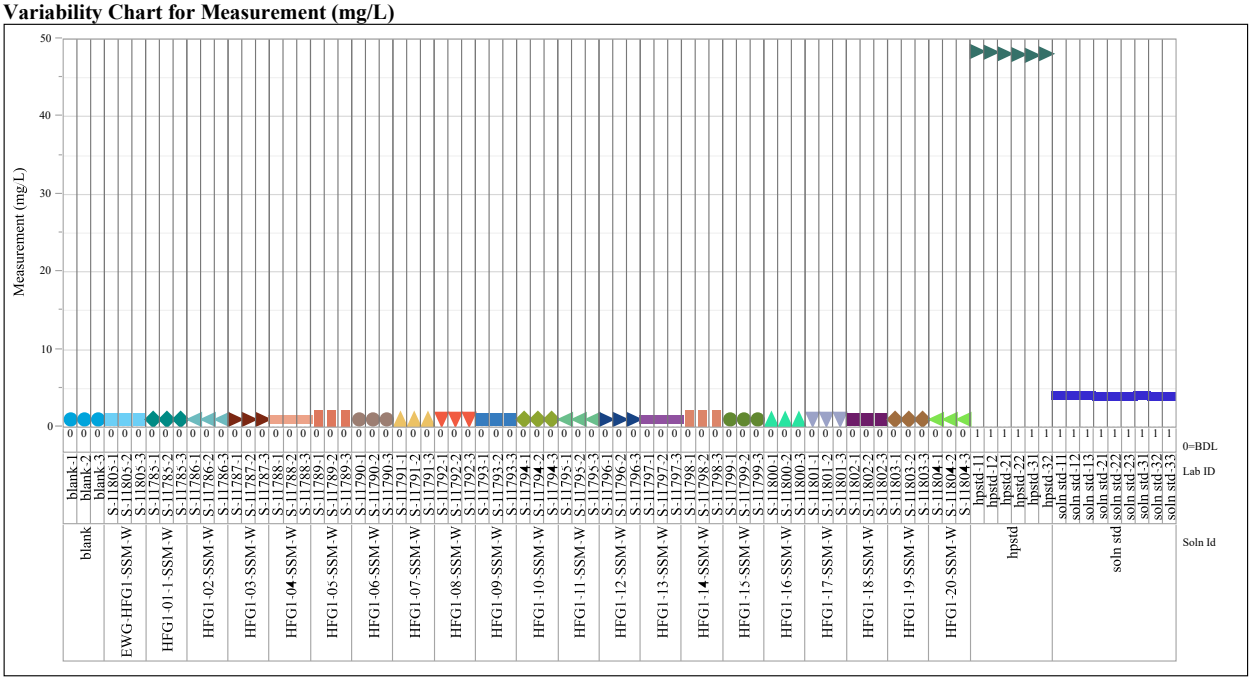
Analyte=Cr (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)



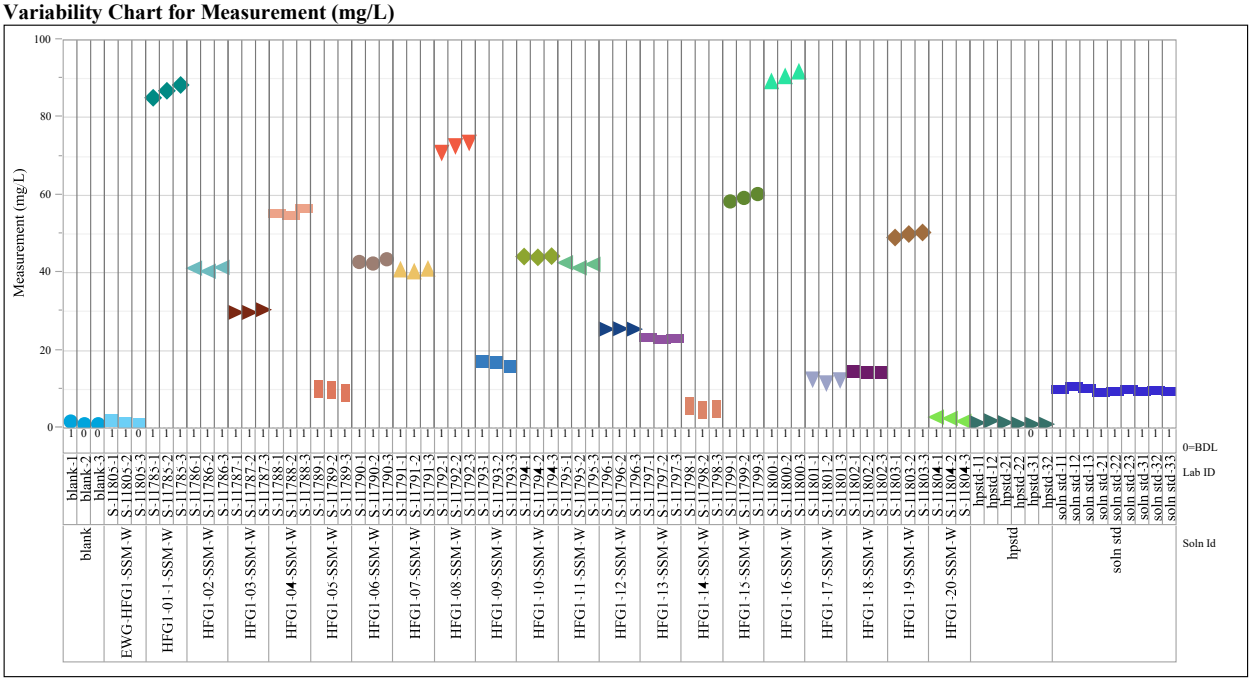
Analyte=F (mg/L), Analysis=IC
Variability Chart for Measurement (mg/L)



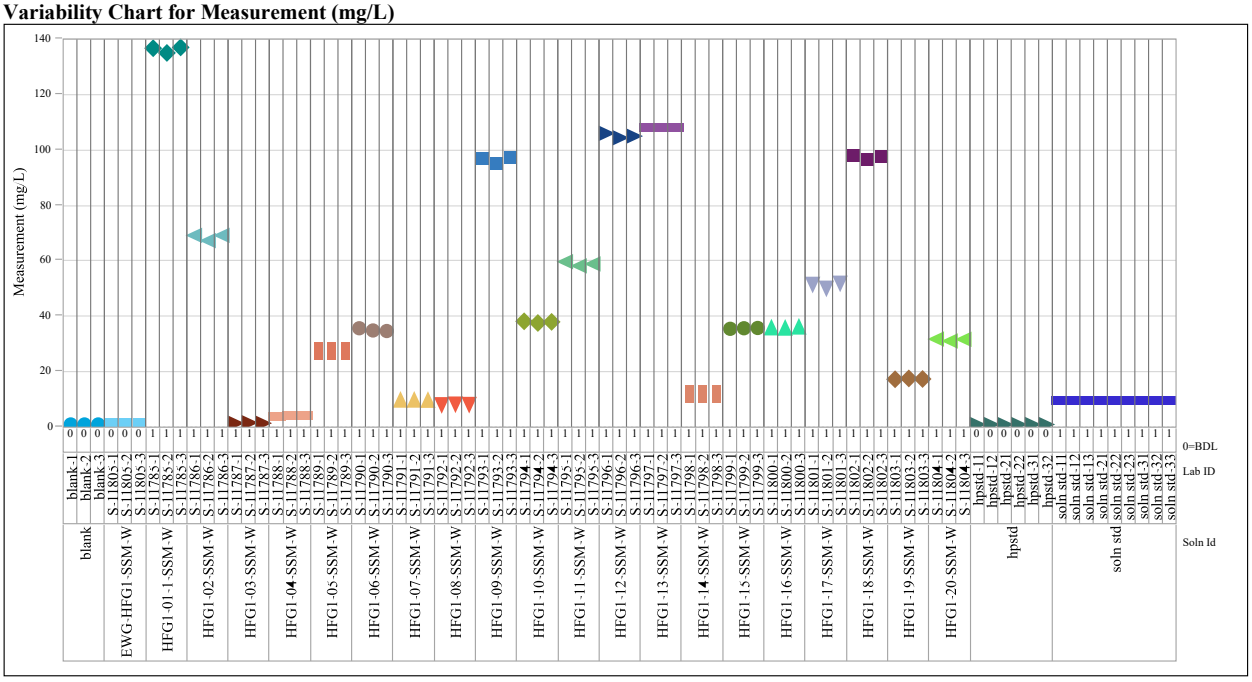
Analyte=Fe (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)



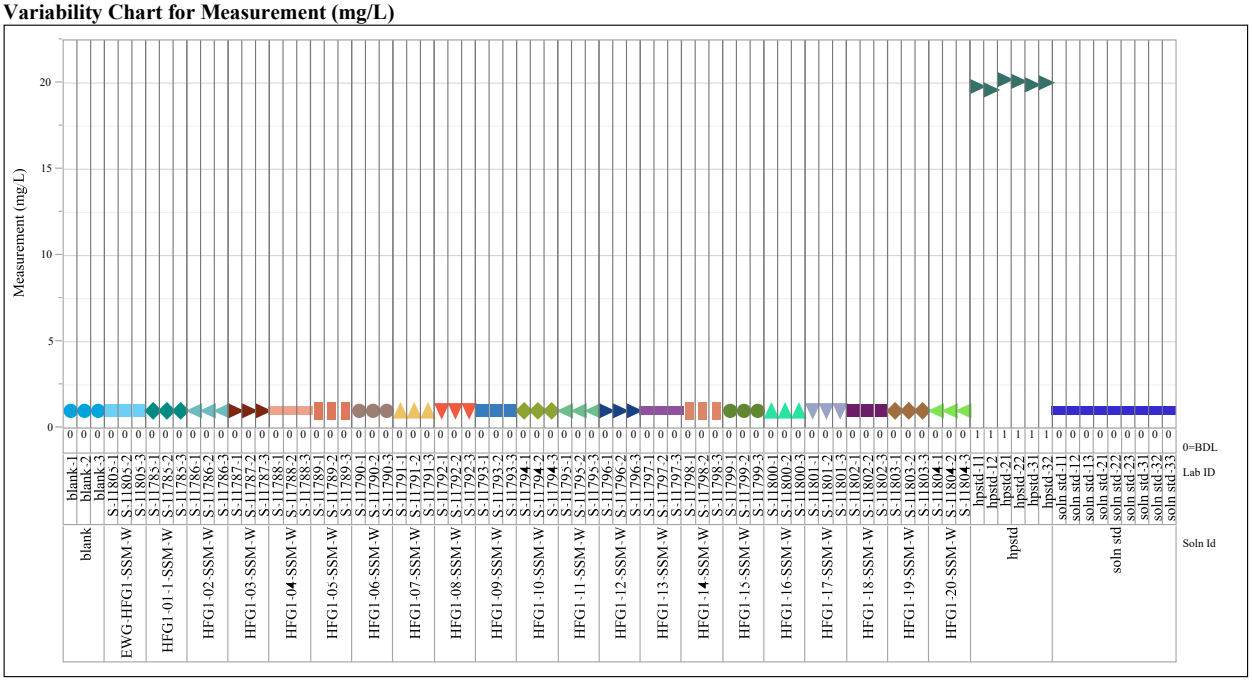
Analyte=K (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)



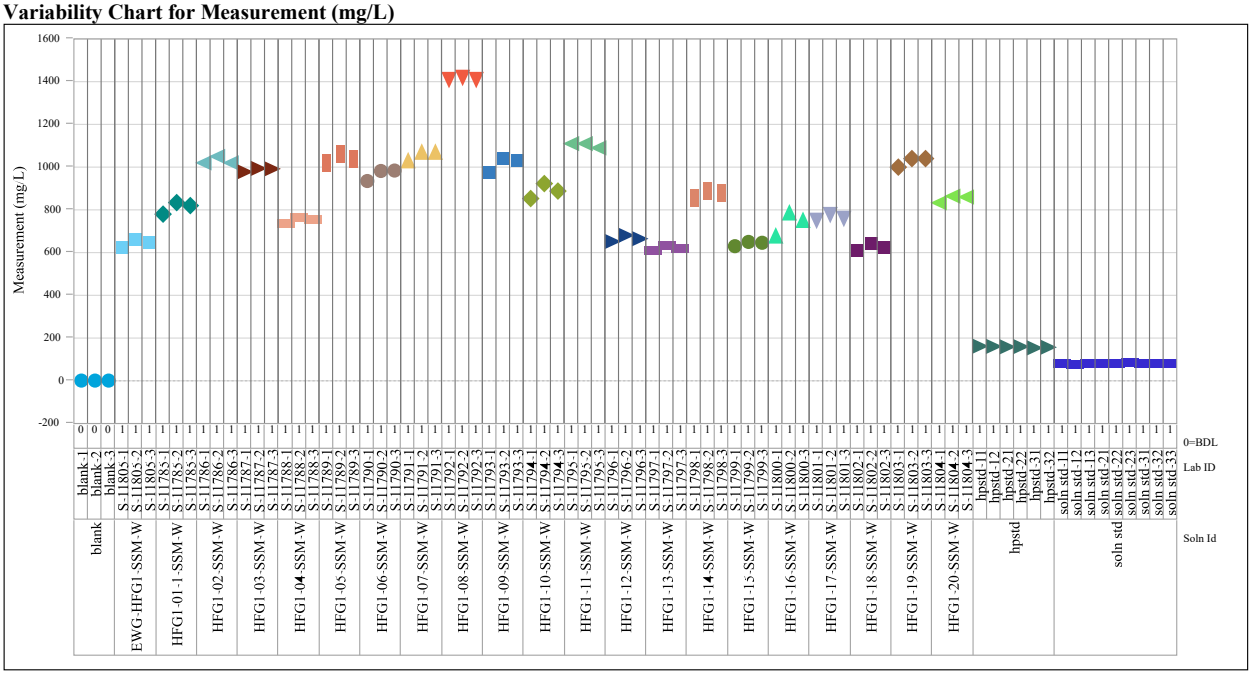
Analyte=Li (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)



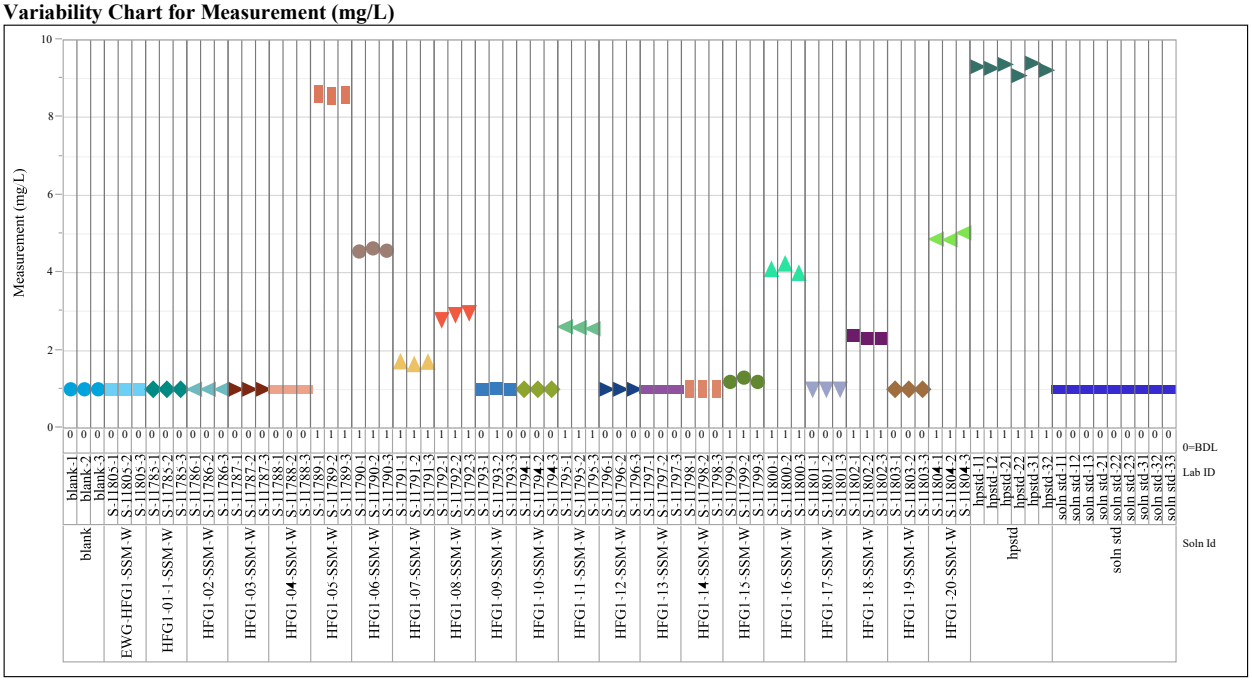
Analyte=Mg (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)



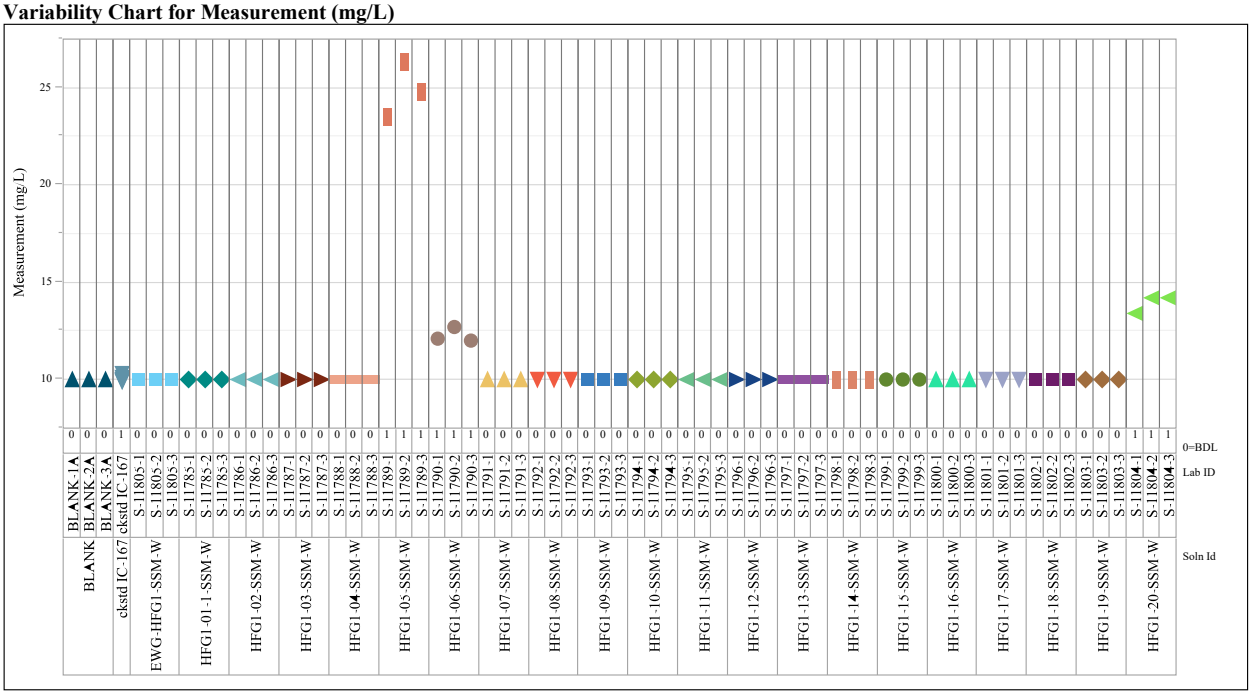
Analyte=Na (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)



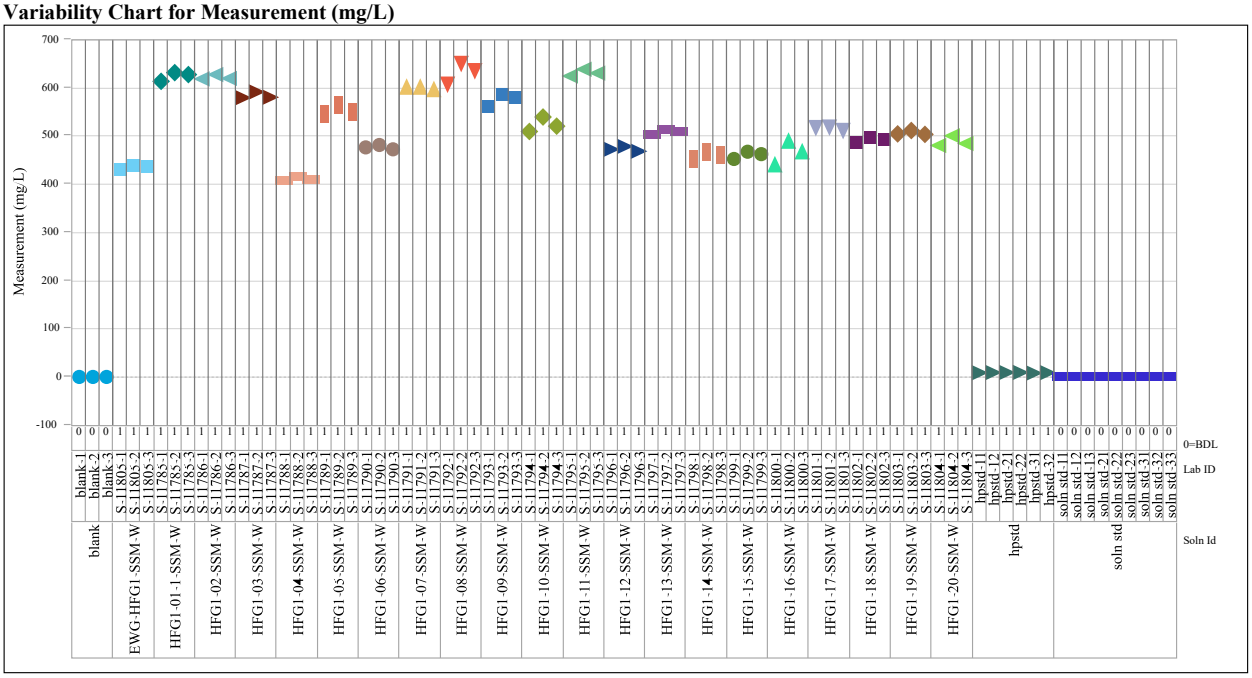
Analyte=P (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)



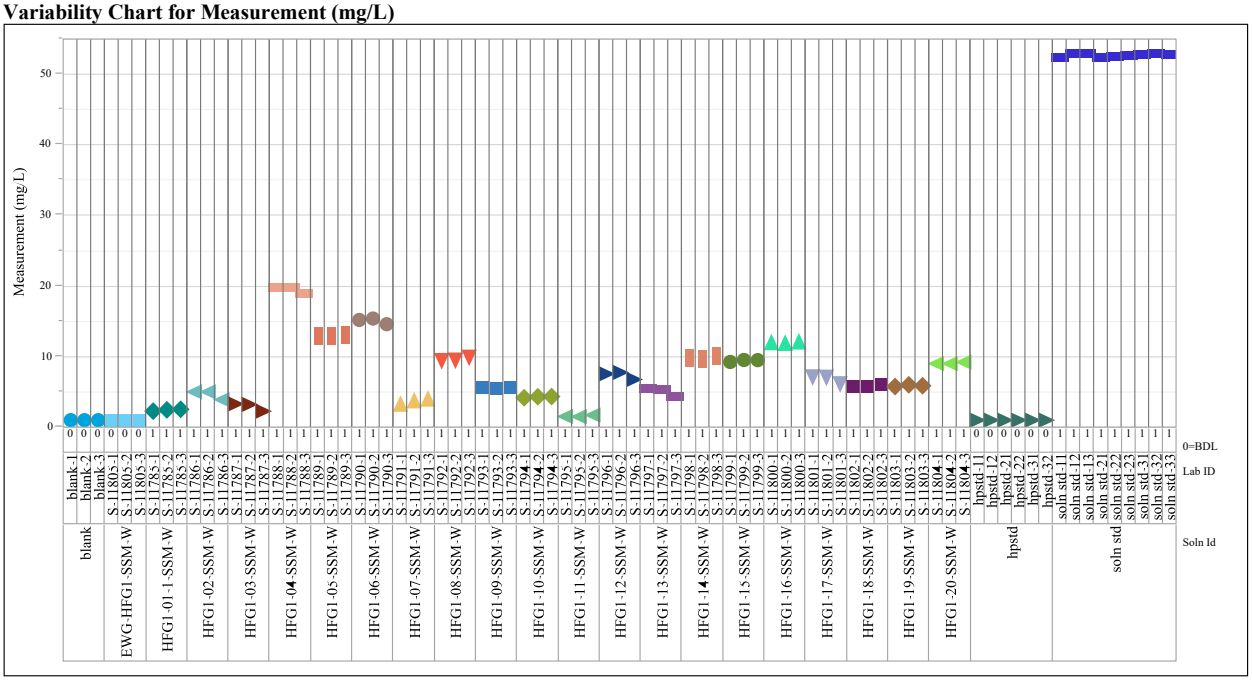
Analyte=PO4 (mg/L), Analysis=IC
Variability Chart for Measurement (mg/L)



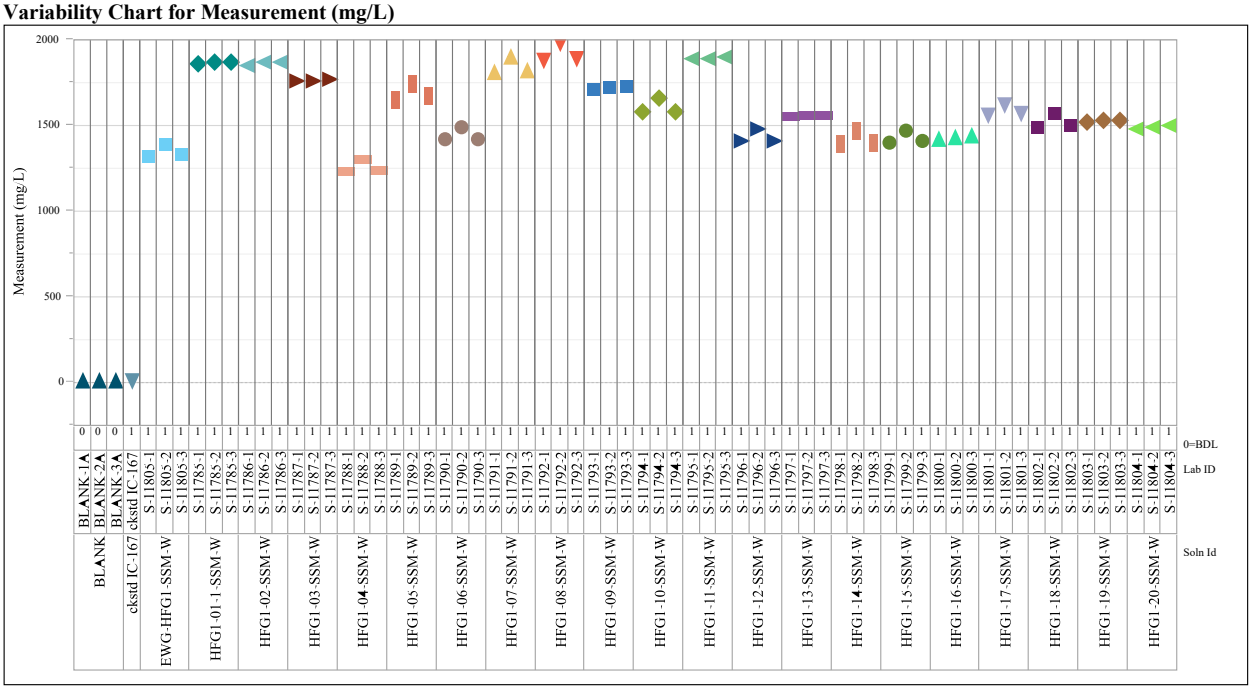
Analyte=S (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)



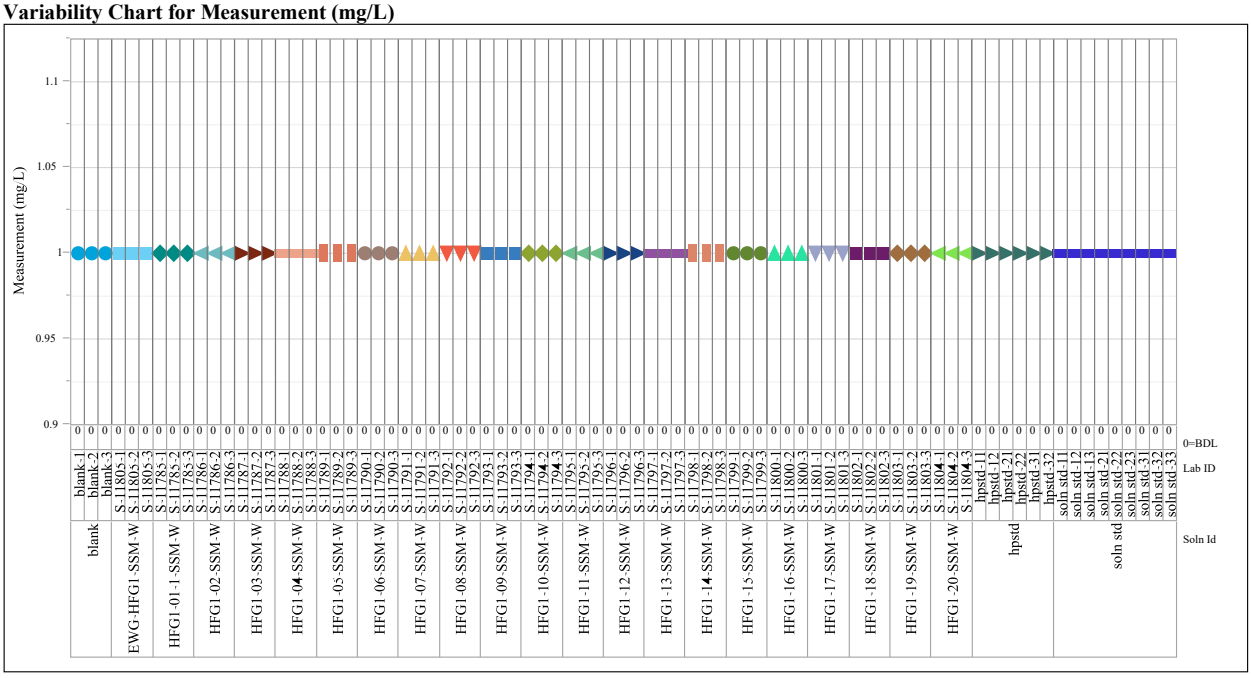
Analyte=Si (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)



Analyte=SO4 (mg/L), Analysis=IC
Variability Chart for Measurement (mg/L)



Analyte=Zn (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)



Analyte=Zr (mg/L), Analysis=ICP
Variability Chart for Measurement (mg/L)

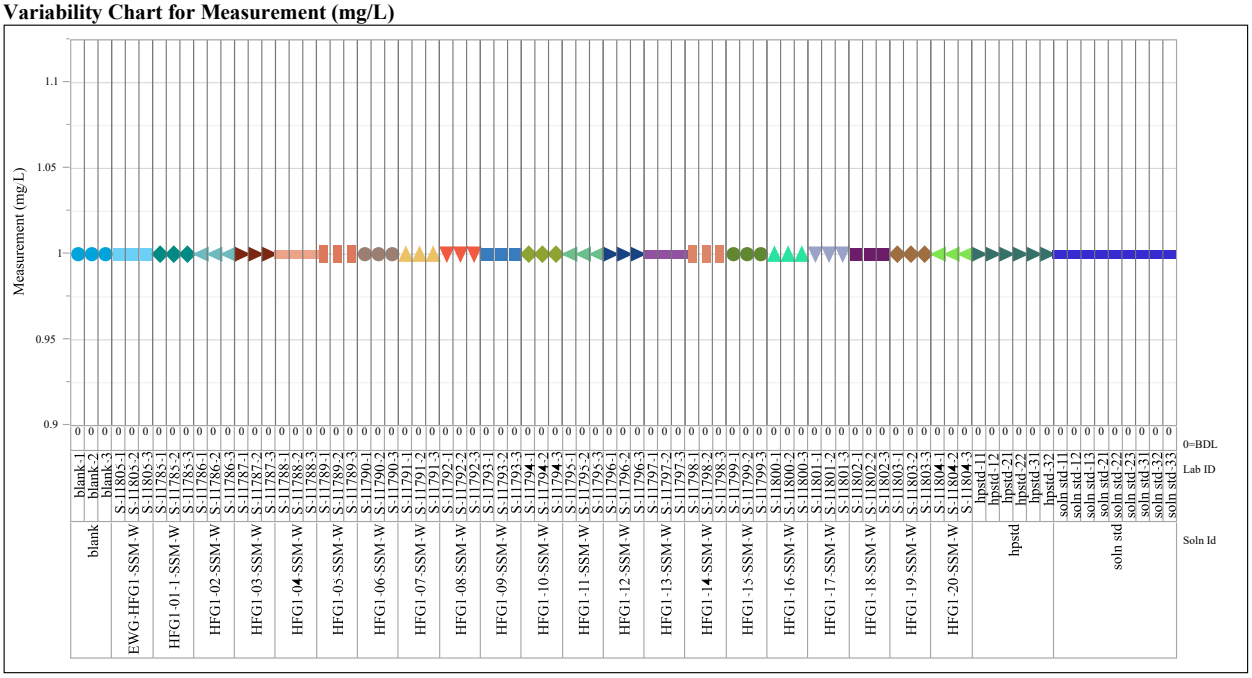
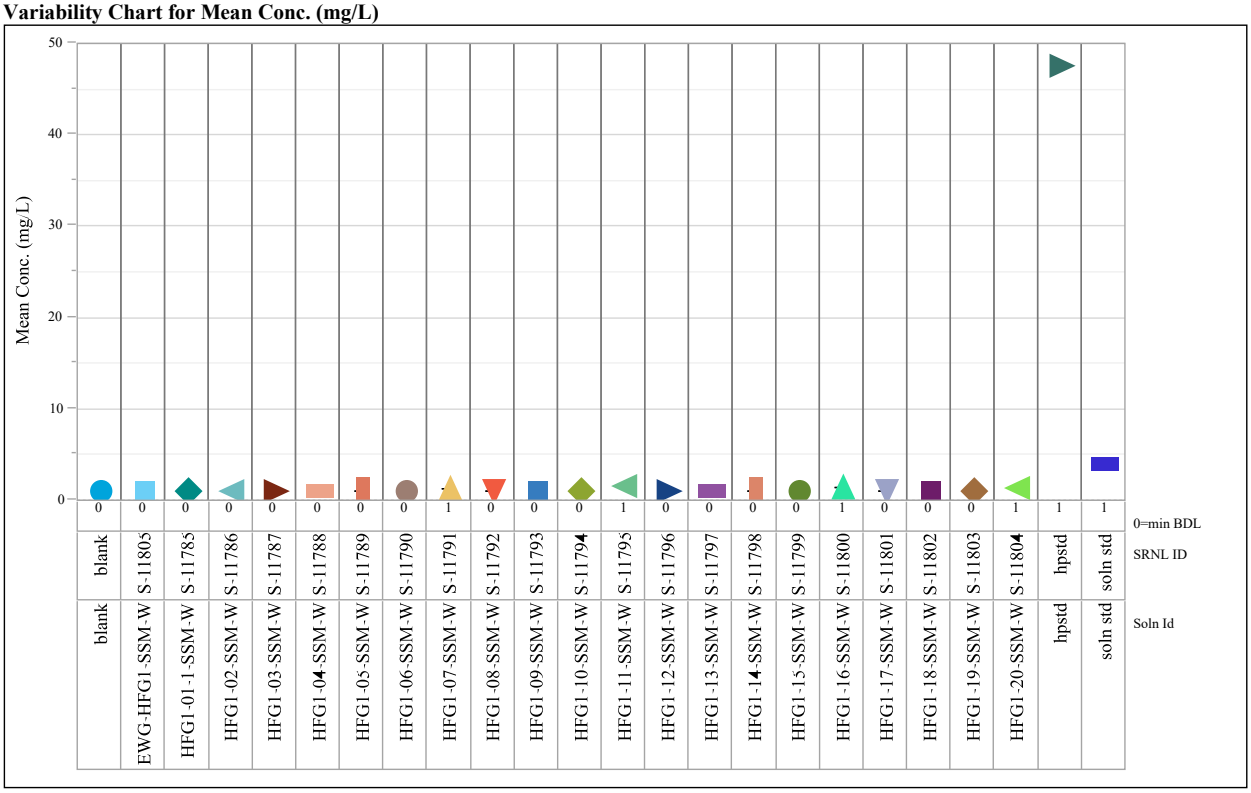


Exhibit B-3. Average Measurements of Wash Solutions by Analyte Grouped by Solution Identifier

Analyte=Al, Analysis=ICP
Variability Chart for Mean Conc. (mg/L)



Analyte=B, Analysis=ICP
Variability Chart for Mean Conc. (mg/L)

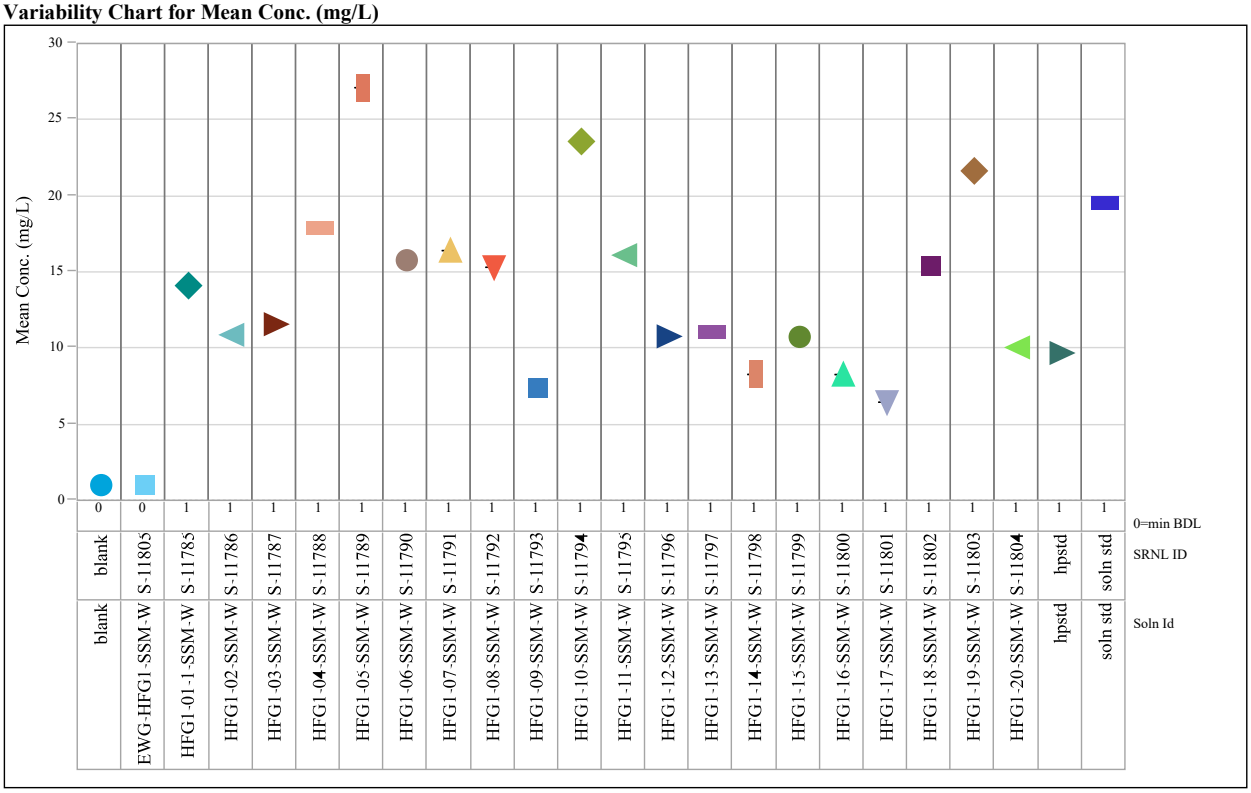
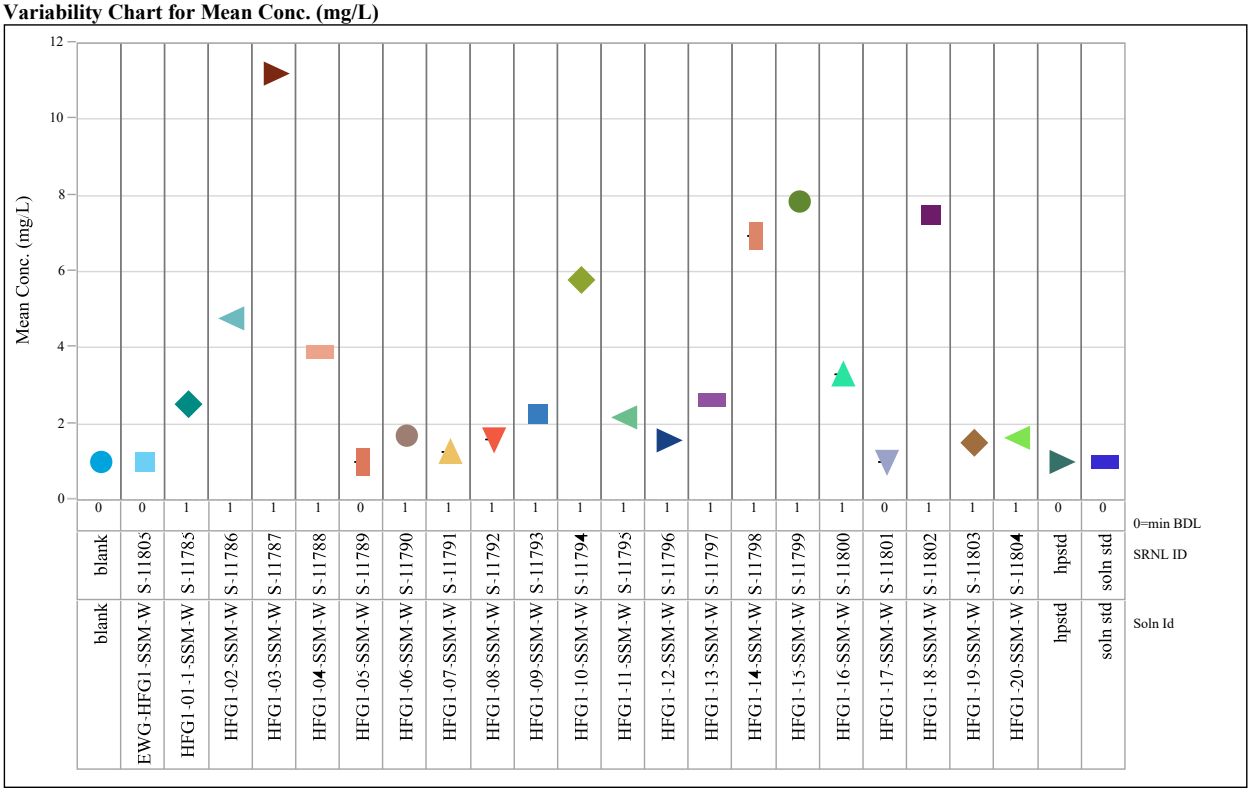


Exhibit B-3. Average Measurements of Wash Solutions by Analyte Grouped by Solution Identifier (continued)

Analyte=Ca, Analysis=ICP
Variability Chart for Mean Conc. (mg/L)



Analyte=Cr, Analysis=ICP
Variability Chart for Mean Conc. (mg/L)

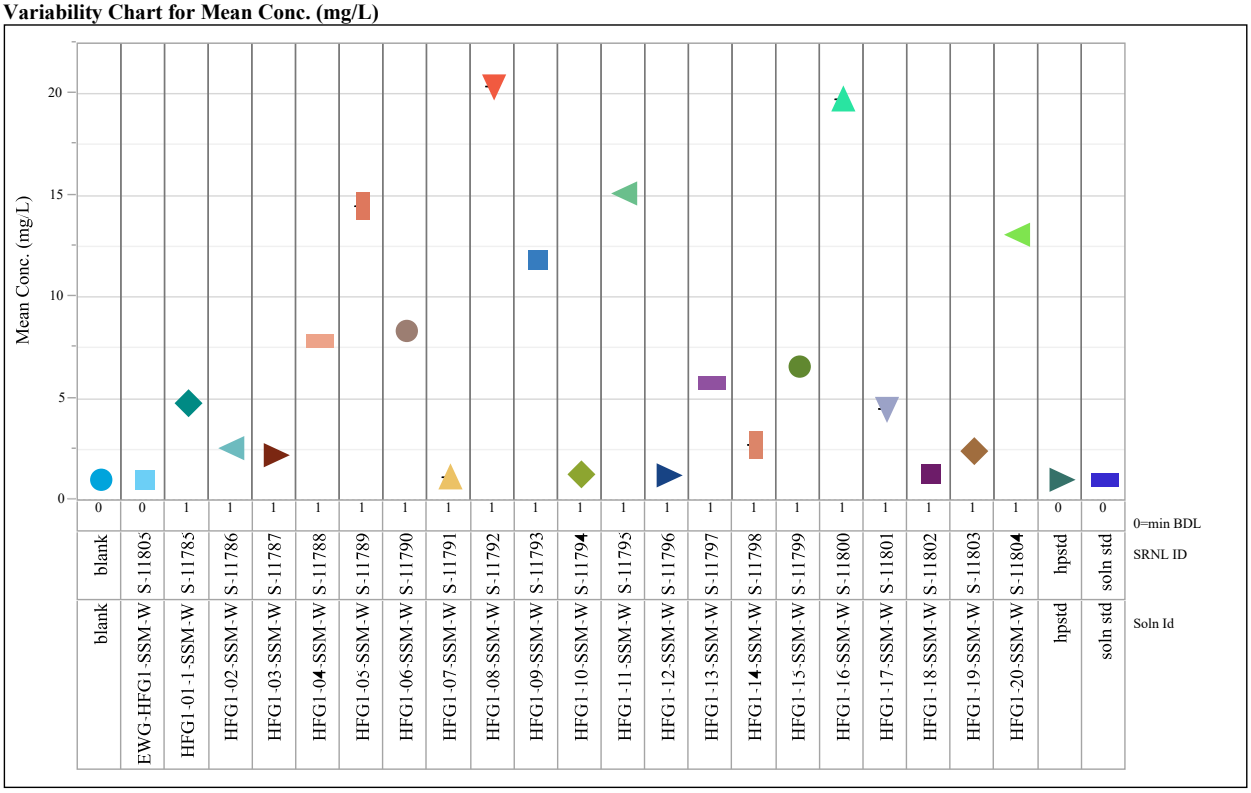
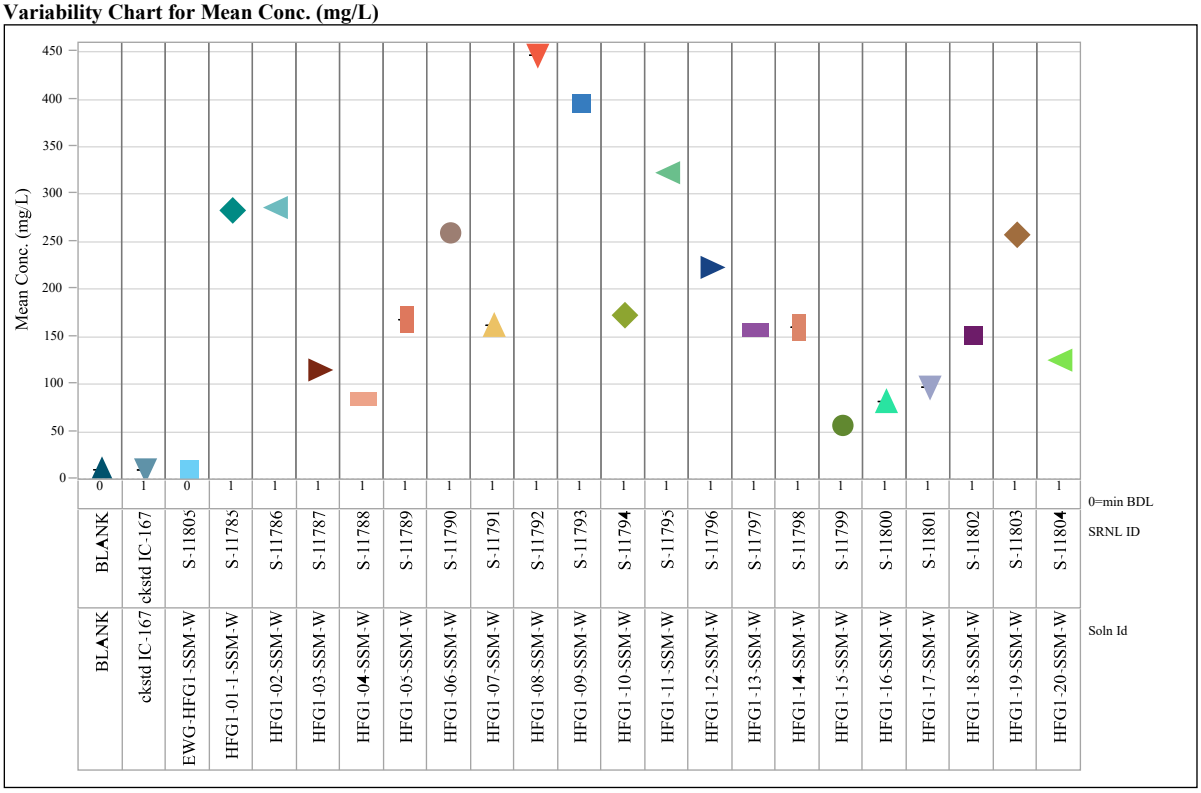


Exhibit B-3. Average Measurements of Wash Solutions by Analyte Grouped by Solution Identifier (continued)

Analyte=F, Analysis=IC
Variability Chart for Mean Conc. (mg/L)



Analyte=Fe, Analysis=ICP
Variability Chart for Mean Conc. (mg/L)

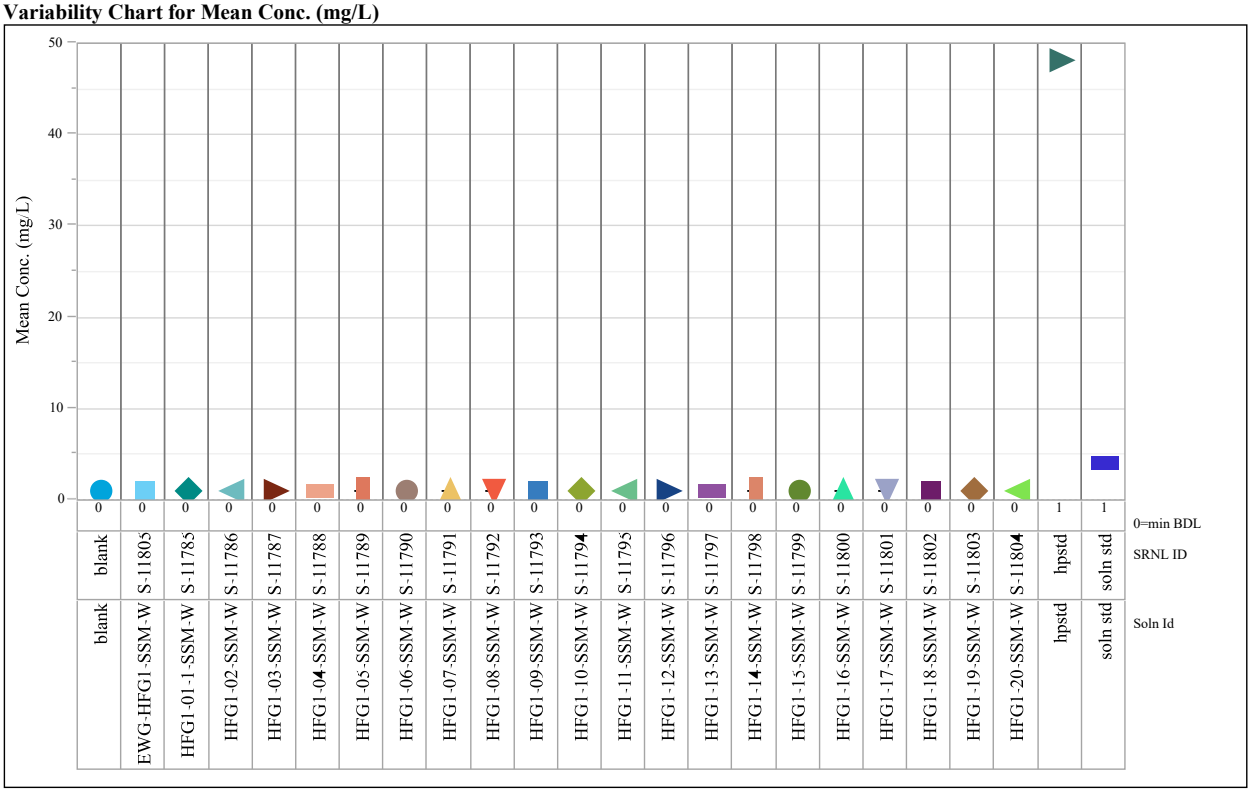
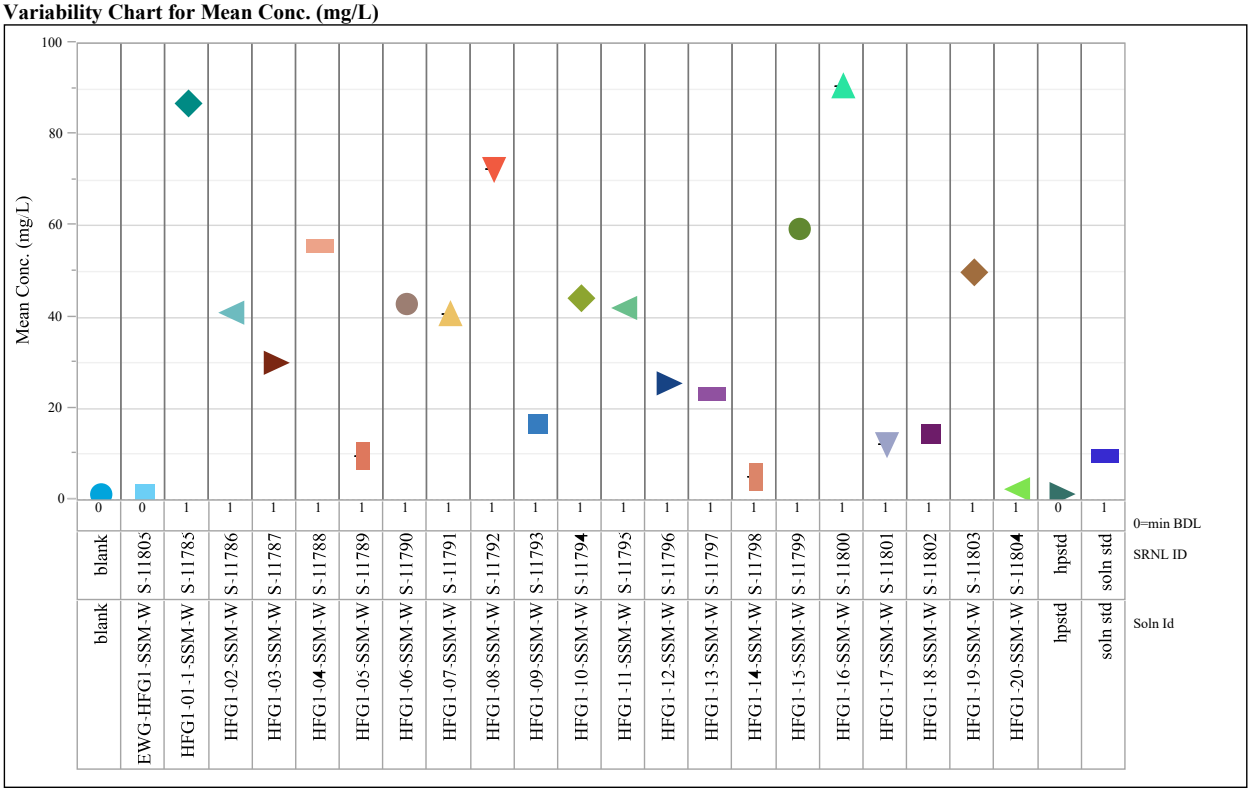


Exhibit B-3. Average Measurements of Wash Solutions by Analyte Grouped by Solution Identifier (continued)

Analyte=K, Analysis=ICP
Variability Chart for Mean Conc. (mg/L)



Analyte=Li, Analysis=ICP
Variability Chart for Mean Conc. (mg/L)

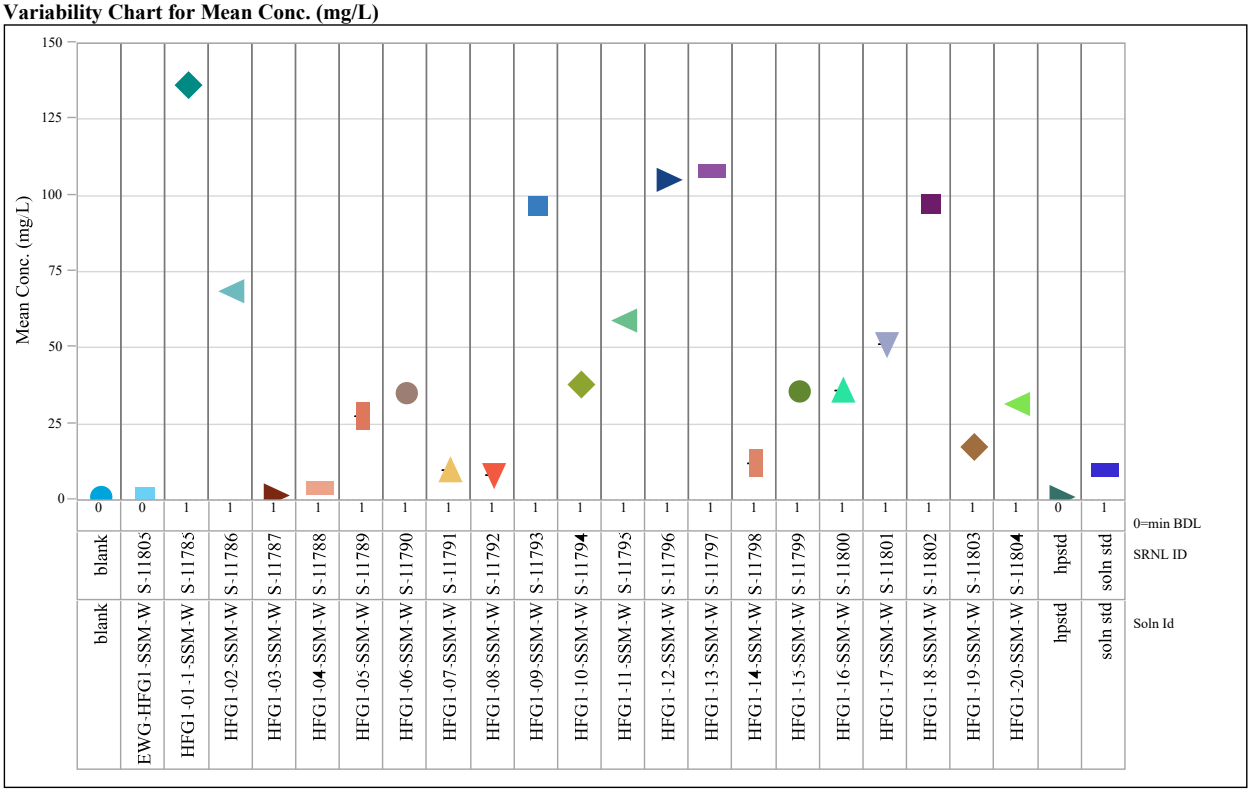
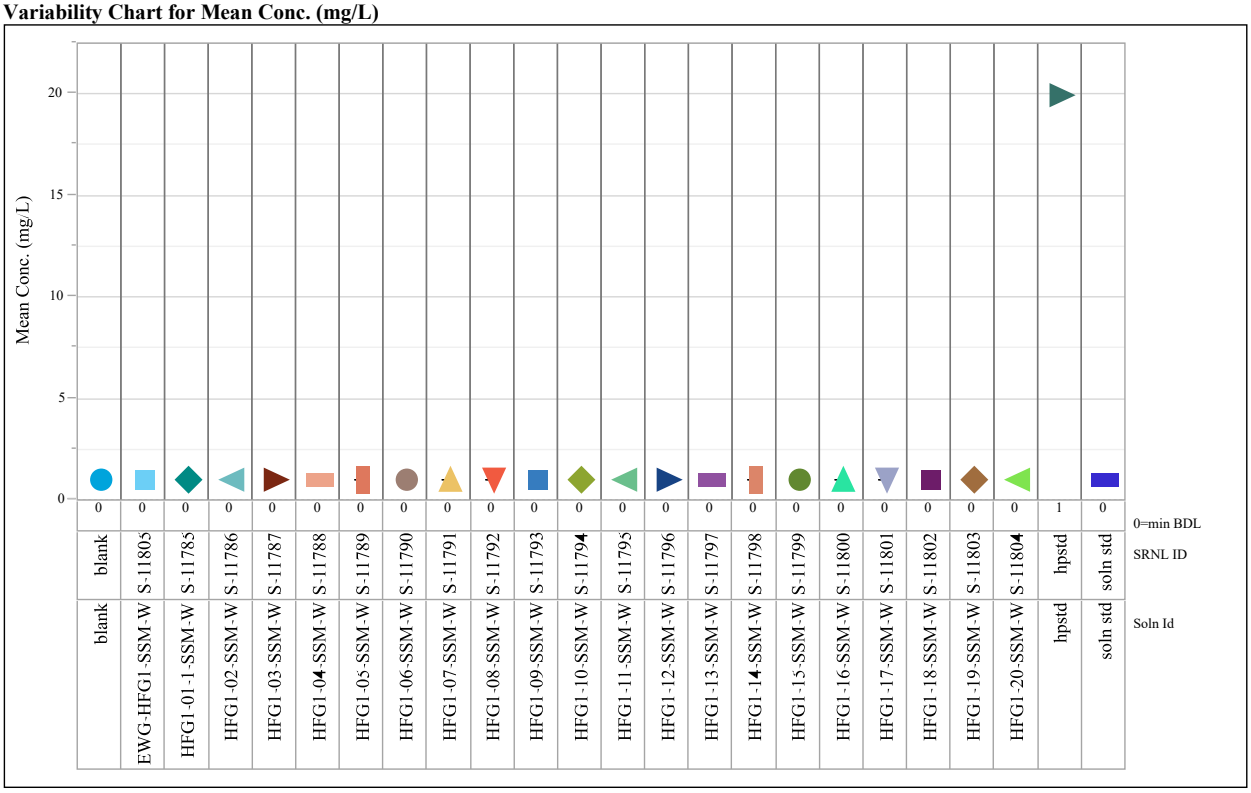


Exhibit B-3. Average Measurements of Wash Solutions by Analyte Grouped by Solution Identifier (continued)

Analyte=Mg, Analysis=ICP
Variability Chart for Mean Conc. (mg/L)



Analyte=Na, Analysis=ICP
Variability Chart for Mean Conc. (mg/L)

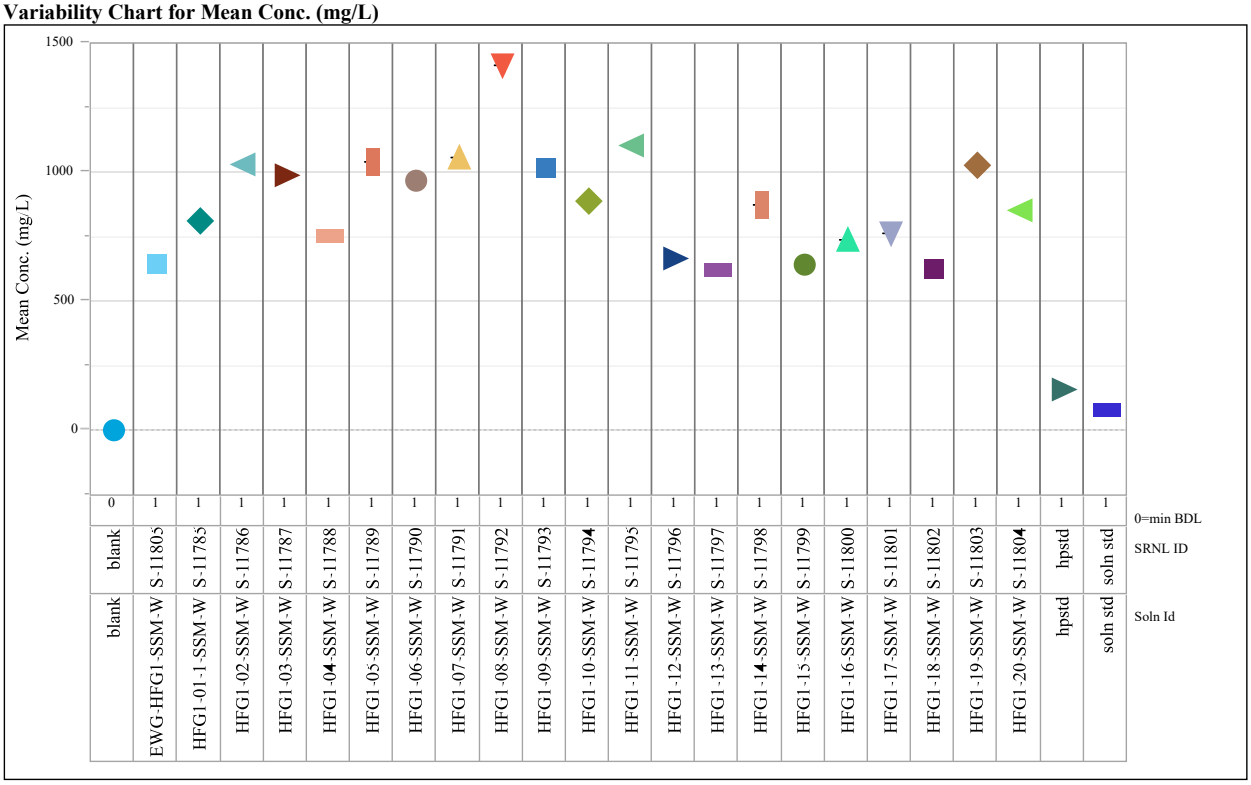
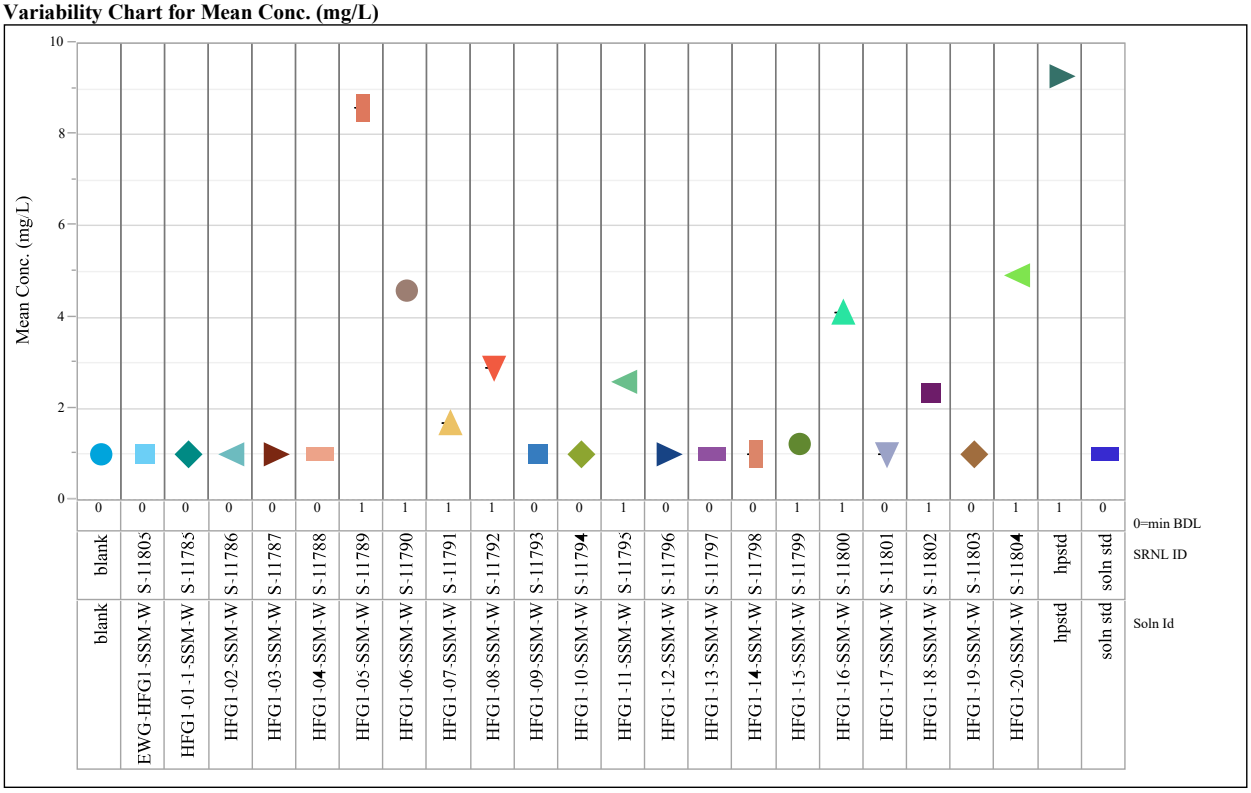


Exhibit B-3. Average Measurements of Wash Solutions by Analyte Grouped by Solution Identifier (continued)

Analyte=P, Analysis=ICP
Variability Chart for Mean Conc. (mg/L)



Analyte=PO4, Analysis=IC
Variability Chart for Mean Conc. (mg/L)

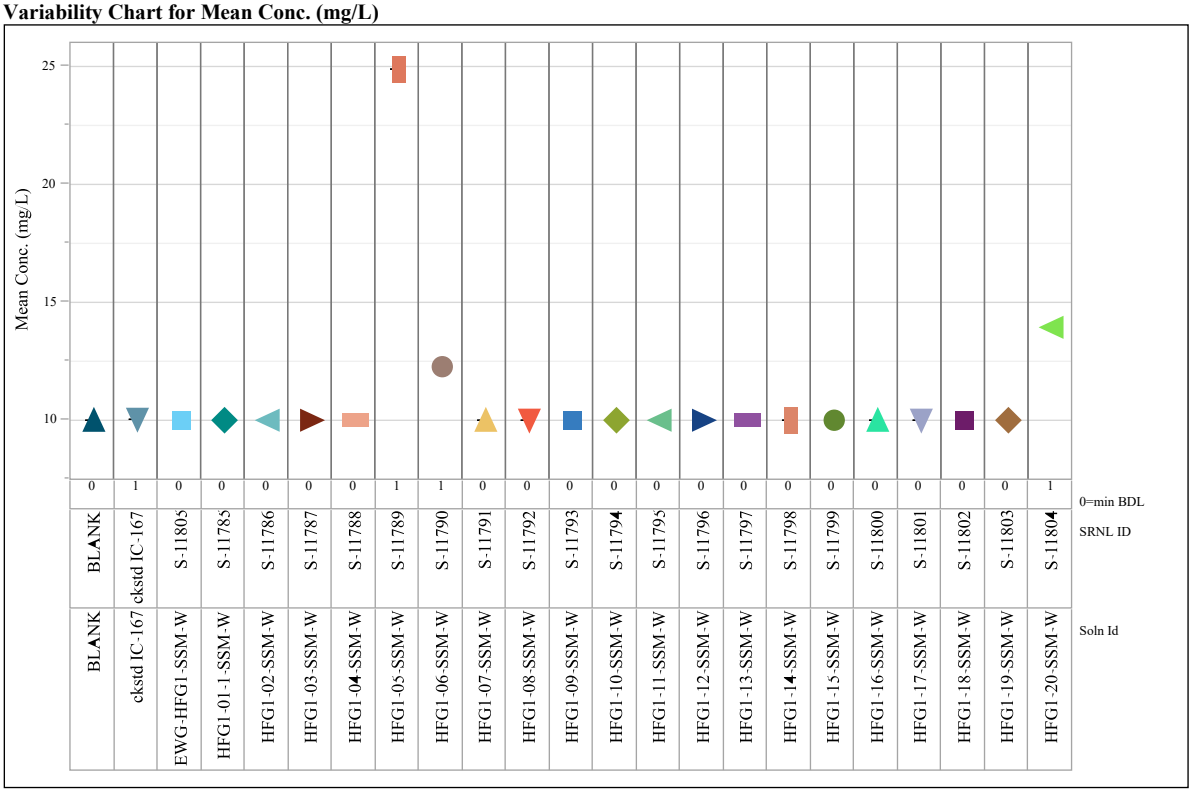
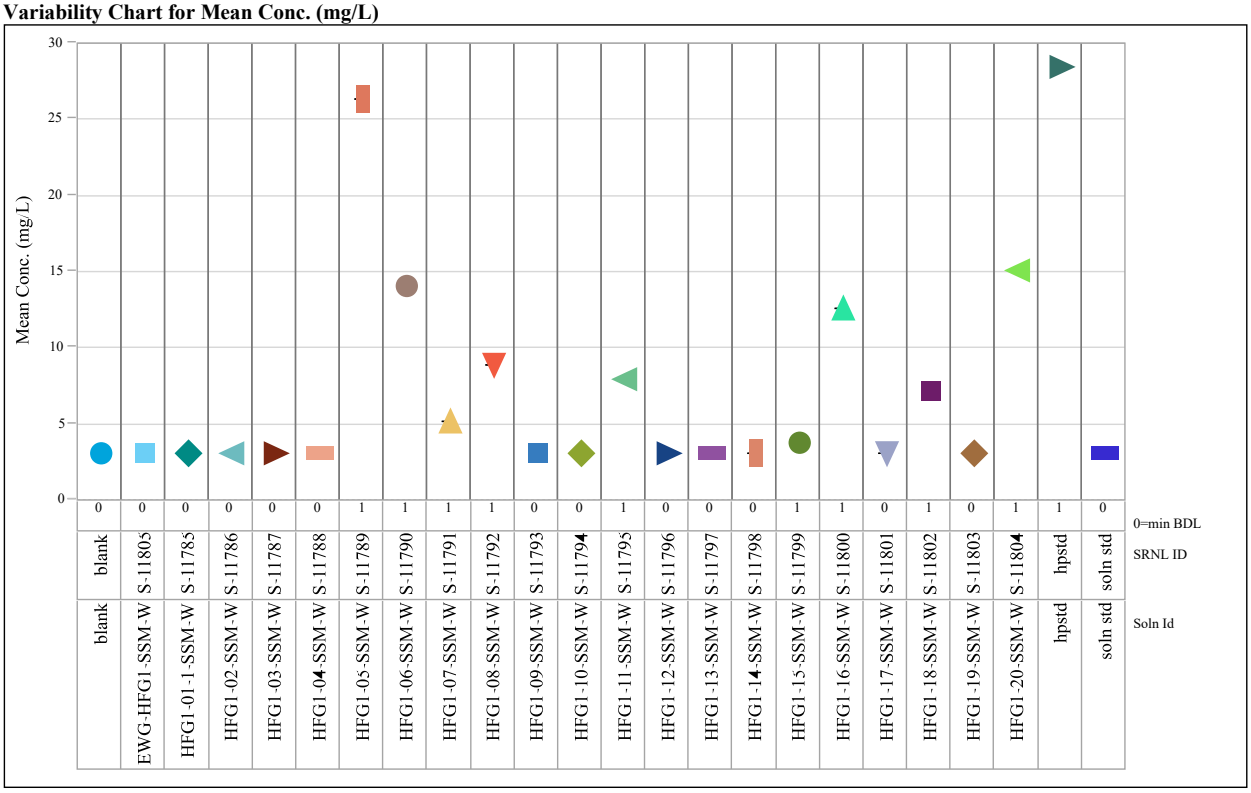


Exhibit B-3. Average Measurements of Wash Solutions by Analyte Grouped by Solution Identifier (continued)

Analyte=PO4, Analysis=ICP
Variability Chart for Mean Conc. (mg/L)



Analyte=S, Analysis=ICP
Variability Chart for Mean Conc. (mg/L)

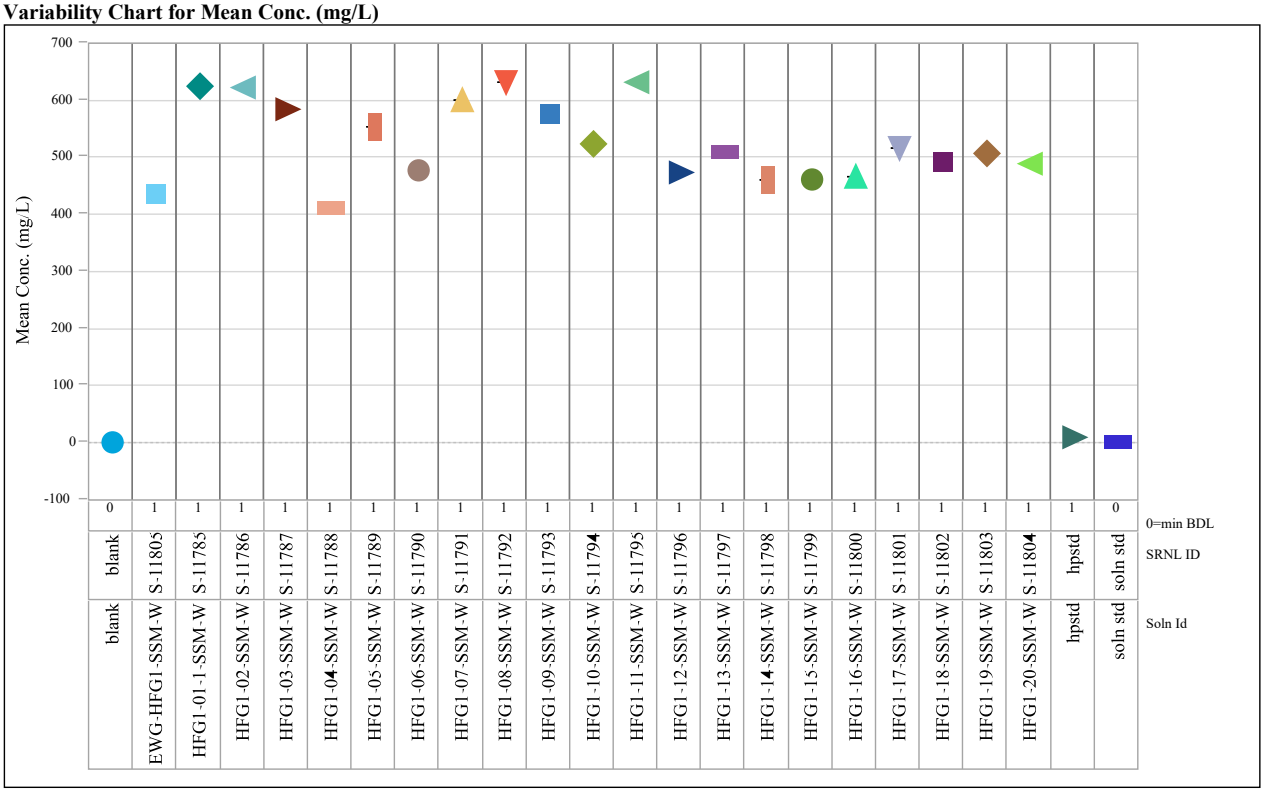
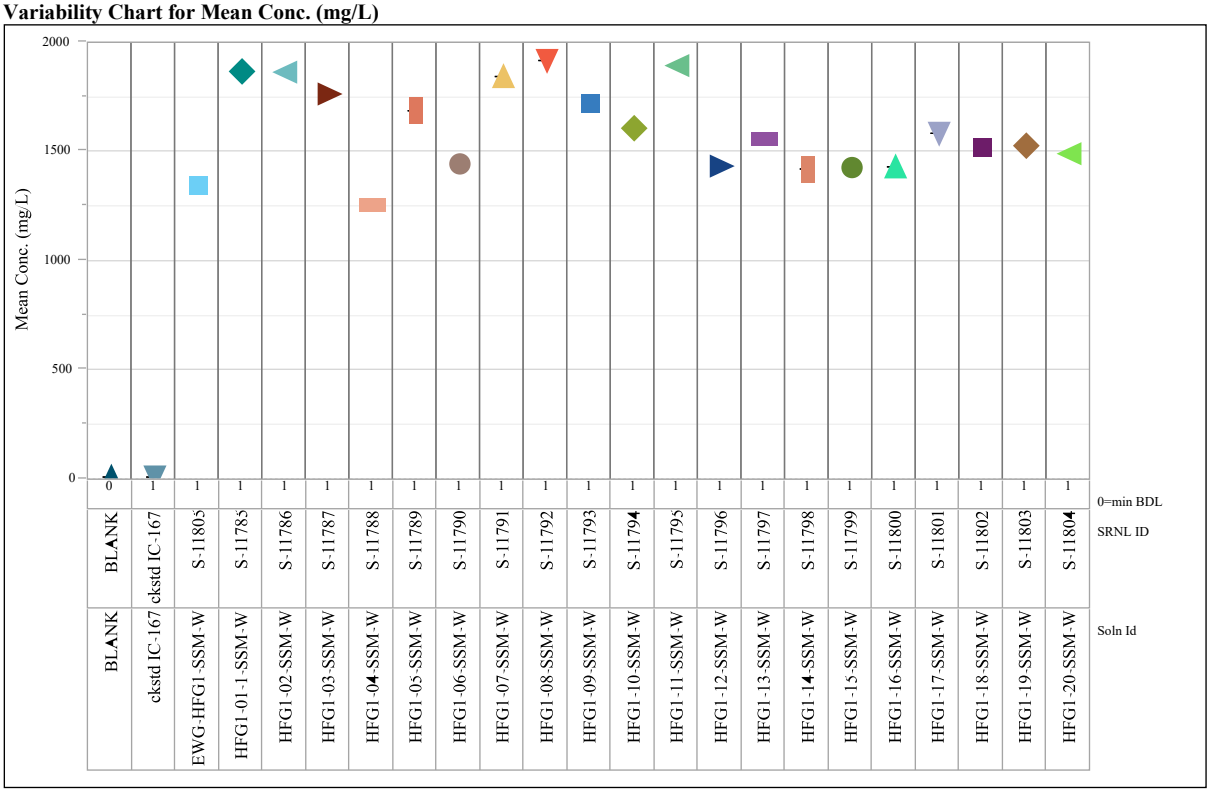


Exhibit B-3. Average Measurements of Wash Solutions by Analyte Grouped by Solution Identifier (continued)

Analyte=SO4, Analysis=IC
Variability Chart for Mean Conc. (mg/L)



Analyte=SO4, Analysis=ICP
Variability Chart for Mean Conc. (mg/L)

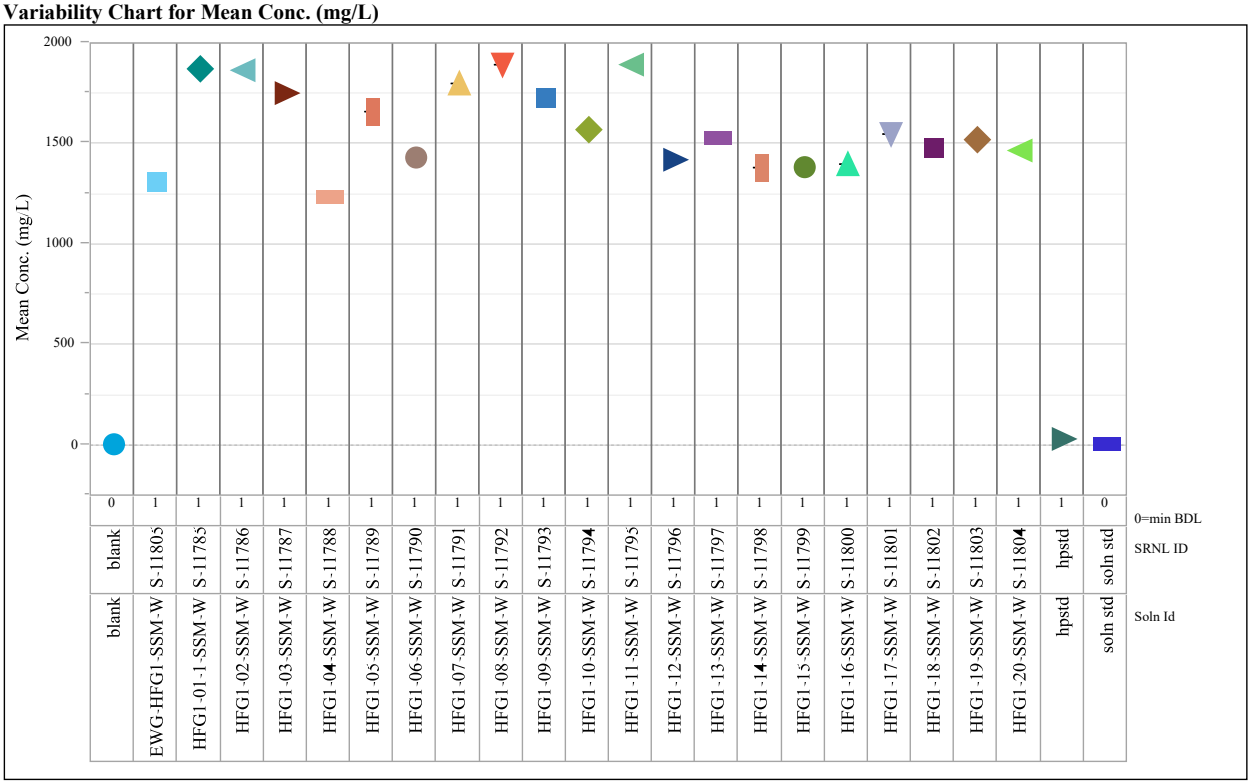
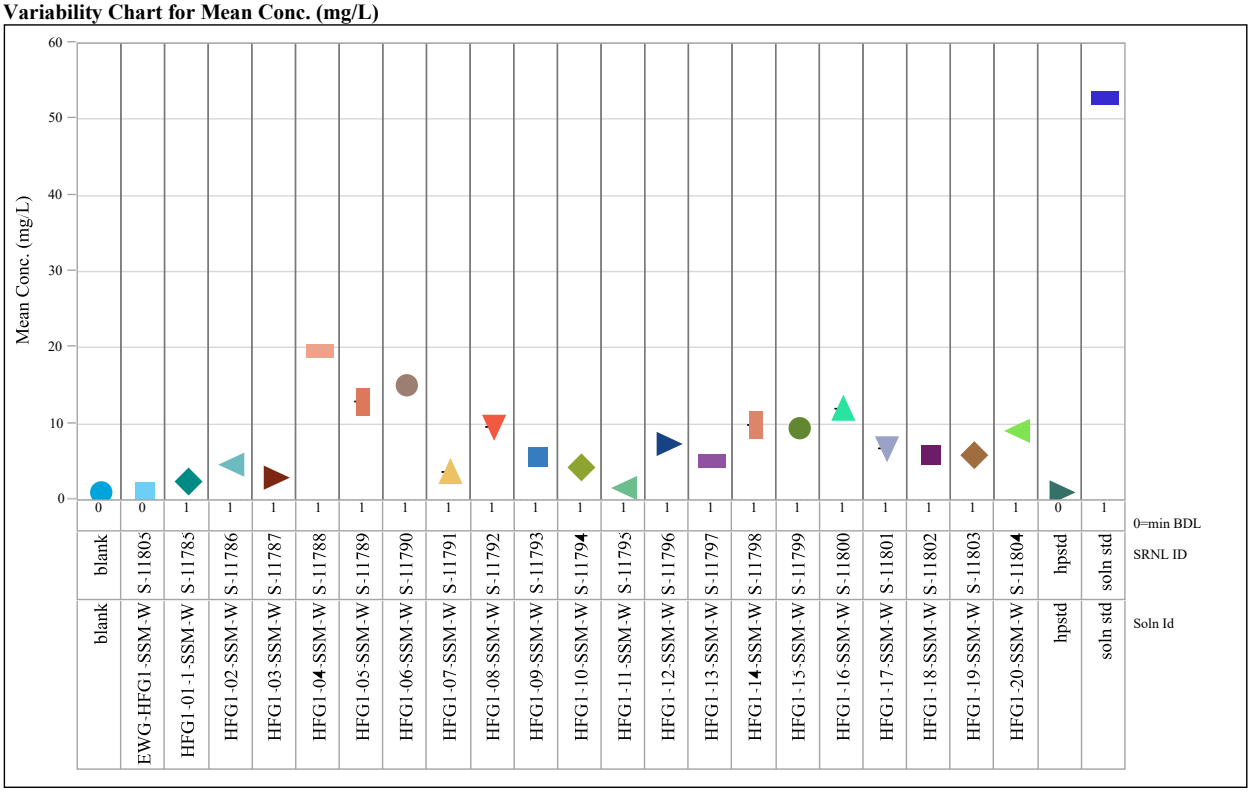


Exhibit B-3. Average Measurements of Wash Solutions by Analyte Grouped by Solution Identifier (continued)

Analyte=Si, Analysis=ICP
Variability Chart for Mean Conc. (mg/L)



Analyte=Zn, Analysis=ICP
Variability Chart for Mean Conc. (mg/L)

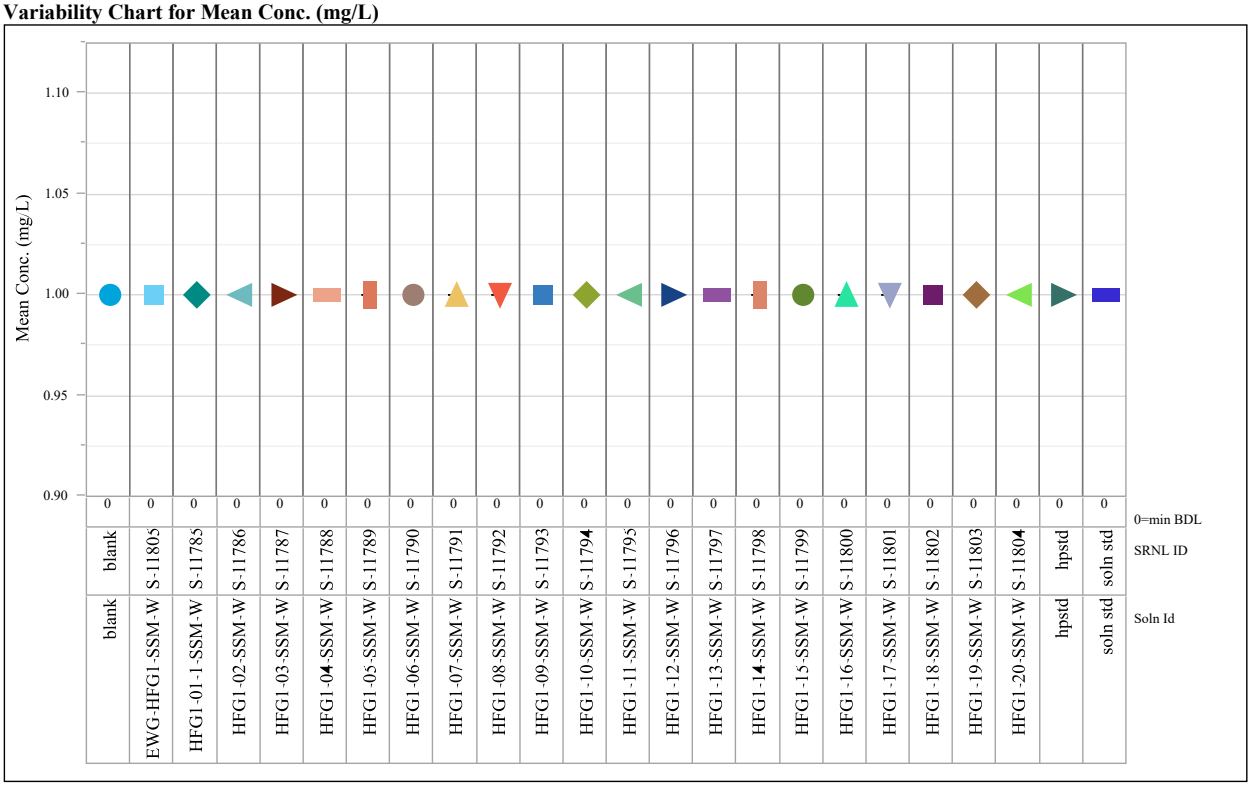
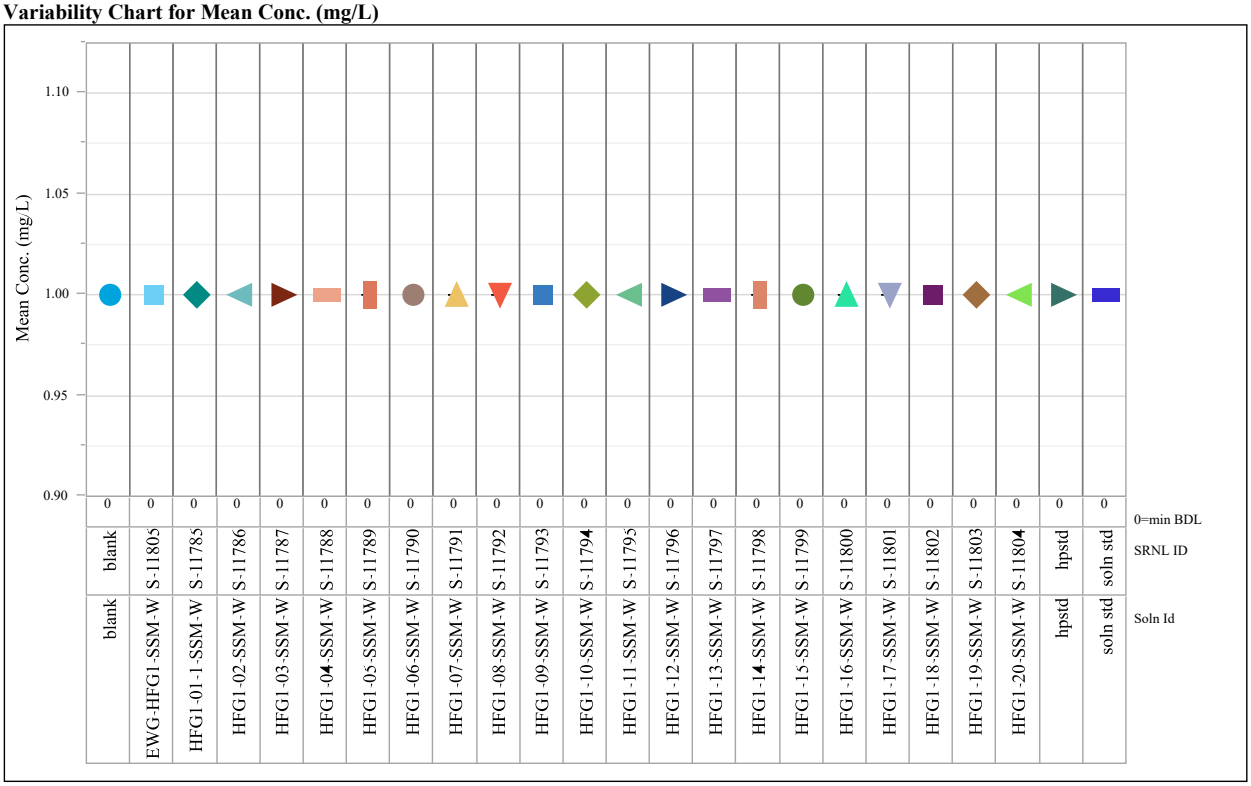


Exhibit B-3. Average Measurements of Wash Solutions by Analyte Grouped by Solution Identifier (continued)

Analyte=Zr, Analysis=ICP
Variability Chart for Mean Conc. (mg/L)



Distribution:

Jake.Amoroso@srnl.doe.gov
CJ.Bannochie@srnl.doe.gov
Alex.Cozzi@srnl.doe.gov
Charles.Crawford@srnl.doe.gov
Elaine_N_Diaz@orp.doe.gov
William.C.Eaton@pnnl.gov
A.Fellinger@srnl.doe.gov
Samuel.Fink@srnl.doe.gov
Terry.Foster@srnl.doe.gov
Brenda.Garcia-Diaz@srnl.doe.gov
Vivianaluxa.Gervasio@pnnl.gov
Holly.Hall@srnl.doe.gov
Erich.Hansen@srnl.doe.gov
Connie.Herman@srnl.doe.gov
Anthony.Howe@srnl.doe.gov
Madison.Hsieh@srnl.doe.gov
Dennis.Jackson@srnl.doe.gov
Tongan.Jin@pnnl.gov
Fabienne.Johnson@srnl.doe.gov
Dongsang.Kim@pnnl.gov
Albert_A_Kruger@orp.doe.gov
Christine.Langton@srnl.doe.gov
Brady.Lee@srnl.doe.gov
Charmayne.Lonergan@pnnl.gov
Joseph.Manna@srnl.doe.gov
Daniel.McCabe@srnl.doe.gov
Kandice.Miles@srnl.doe.gov
Gregg.Morgan@srnl.doe.gov
Frank.Pennebaker@srnl.doe.gov
Amy.Ramsey@srnl.doe.gov
William.Ramsey@srnl.doe.gov
Whitney.Riley@srnl.doe.gov
Renee.Russell@pnnl.gov
Eric.Skidmore@srnl.doe.gov
Anna.Stanfield@srnl.doe.gov
Michael.Stone@srnl.doe.gov
John.Vienna@pnnl.gov
Boyd.Wiedenman@srnl.doe.gov
Richard.Wyrwas@srnl.doe.gov
Records Administration (EDWS)