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Product Consistency Test Results for the LAW HPVR Glasses

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REVIEWS AND APPROVALS

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EXECUTIVE SUMMARY

This report summarizes the chemical analysis of Product Consistency Test (PCT) leachates received from Pacific Northwest National Laboratory (PNNL). The leachates are from a series of simulated nuclear waste glasses designated Low-Activity Waste High PCT and VHT Response (LAW HPVR) glasses that were designed and fabricated at PNNL. The glasses included both quenched and canister centerline cooled glasses. The reported data will be used in the development, validation, and implementation of enhanced property/composition models for waste glass vitrification at Hanford.

The elemental release for the study glasses is reported as normalized concentration (NC_i). NC_i of several elements was computed for both the target and measured glass compositions, which were similar, resulting in no significant differences when computing the NC_i values. The majority of the glasses exhibited NC_B, NC_{Na}, and NC_{Si} values that were greater than the Hanford Tank Waste Treatment Plant (WTP) low-activity waste constraint of 4 g/L. Several blank solutions included with the study glasses had K, Na, and Si concentrations above the analytical detection limit. Additionally, several of the reference glasses that were included with the study glasses had Na concentrations that were higher than expected. The unexpected analyte concentrations in the reference glass and blank solutions were insignificant with respect to the reported NC_i values, and are noted for completeness and their experimental relevance.

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LIST OF ABBREVIATIONS

ARM-1	Approved Reference Material-1
ASTM	American Society for Testing and Materials
BDL	below detection limit
CCC	canister centerline cooled
DF	dilution factor
DOE	Department of Energy
HPVR	High PCT and VHT Response
ICP-OES	inductively coupled plasma – optical emission spectroscopy
ID	identifier
LAW	low-activity waste
LRM	low-activity reference material
NCi	normalized concentration of element "i"
ORP	Office of River Protection
PCT	Product Consistency Test
PNNL	Pacific Northwest National Laboratory
Q	quenched
%RSD	percent relative standard deviation
seq.	sequence
SRNL	Savannah River National Laboratory
SRS	Savannah River Site
std	High Purity Standards ICP multi-element custom solution SM-744-013
TTQAP	Task Technical and Quality Assurance Plan
VHT	Vapor Hydration Test
wt.%	weight percent
WTP	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 56 million gallons of radioactive waste historically stored in 177 underground tanks. The Office of River Protection (ORP) has requested that the Savannah River National Laboratory (SRNL) contribute in areas of recognized capabilities and expertise for glass waste form development to support successful startup of the WTP.

Successful efforts have allowed for demonstration of greatly enhanced treatment efficiencies of those projected from the minimum requirements set forth in the WTP Contract[a]. Additional flexibility and expansion of the qualified glass forming region are the current focus.[1] SRNL support of this work is defined in the Task Technical and Quality Assurance Plan (TTQAP).[2]

This report provides the chemical analysis of the Product Consistency Test (PCT) leachates from the Low-Activity Waste High PCT and VHT Response (LAW HPVR) glasses, a series of simulated nuclear waste glasses designed and fabricated at the Pacific Northwest National Laboratory (PNNL). The PCT leachates were from both quenched (Q) and canister centerline cooled (CCC)[b] glasses. The glasses were part of a broader study to evaluate the influence of glass composition on chemical durability, sulfur retention, and other properties.[3] These data will be used in the development, validation, and implementation of enhanced property/composition models for nuclear waste glasses.[1]

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 (SRS) Manual E7, Procedure 2.60.[4] SRNL documents the extent and type of review using the SRNL Technical Report Design Checklist contained in WSRC-IM-2002-00011, Rev. 2.[5] Laboratory data for this study were recorded in the SRNL Electronic Laboratory Notebook system, experiment L6390-00441-05. The leachates were provided by PNNL following a Task Plan.[1]

2.2 Glasses Selected for Study

The glass compositions referred to in this study were selected and fabricated by PNNL. PNNL subsequently performed the ASTM C1285 PCT Method A[6] on quenched (Q) and canister centerline cooled (CCC) versions of each of the study glasses. Both the approved reference material (ARM) and the low-activity reference material (LRM) glasses as well as blank solutions were included in the PCT in accordance to the ASTM.[1] The resulting PCT leachates were analyzed at SRNL for chemical analysis. Identifiers (ID) for the PCT leachates are listed in Table 2-1.

[a] Contract DE-AC27-01RV14136, as amended, U.S. Department of Energy, Richland, WA (2000).
[b] Memorandum, Canister Centerline Cooling Data, Revision 1, CCN: 074851, RPP-WTP, October 29, 2003.

Table 2-1. Identifiers for the PCT Leachates

PNNL Solution ID	Lab ID	PNNL Solution ID	Lab ID
LAW-HPVR-01-1-Q-PCT-A	S-13996	LAW-HPVR-14-Q-PCT-A	S-14045
LAW-HPVR-01-1-Q-PCT-B	S-13997	LAW-HPVR-14-Q-PCT-B	S-14046
LAW-HPVR-01-1-Q-PCT-C	S-13998	LAW-HPVR-14-Q-PCT-C	S-14047
LAW-HPVR-02-1-Q-PCT-A	S-13999	LAW-HPVR-15-Q-PCT-A	S-14048
LAW-HPVR-02-1-Q-PCT-B	S-14000	LAW-HPVR-15-Q-PCT-B	S-14049
LAW-HPVR-02-1-Q-PCT-C	S-14001	LAW-HPVR-15-Q-PCT-C	S-14050
LAW-HPVR-03-1-Q-PCT-A	S-14002	LRM-STD-PCT-A	S-14051
LAW-HPVR-03-1-Q-PCT-B	S-14003	LRM-STD-PCT-B	S-14052
LAW-HPVR-03-1-Q-PCT-C	S-14004	LRM-STD-PCT-C	S-14053
LAW-HPVR-04-1-Q-PCT-A	S-14005	MQ WATER BLK-PCT-A	S-14054
LAW-HPVR-04-1-Q-PCT-B	S-14006	MQ WATER BLK-PCT-B	S-14055
LAW-HPVR-04-1-Q-PCT-C	S-14007	LAW-HPVR-16-Q-PCT-A	S-14056
LAW-HPVR-05-Q-PCT-A	S-14008	LAW-HPVR-16-Q-PCT-B	S-14057
LAW-HPVR-05-Q-PCT-B	S-14009	LAW-HPVR-16-Q-PCT-C	S-14058
LAW-HPVR-05-Q-PCT-C	S-14010	LAW-HPVR-17-Q-PCT-A	S-14059
LRM-STD-PCT-A	S-14011	LAW-HPVR-17-Q-PCT-B	S-14060
LRM-STD-PCT-B	S-14012	LAW-HPVR-17-Q-PCT-C	S-14061
LRM-STD-PCT-C	S-14013	LAW-HPVR-18-Q-PCT-A	S-14062
MQ WATER BLK-PCT-A	S-14014	LAW-HPVR-18-Q-PCT-B	S-14063
MQ WATER BLK-PCT-B	S-14015	LAW-HPVR-18-Q-PCT-C	S-14064
LAW-HPVR-06-Q-PCT-A	S-14016	LAW-HPVR-19-Q-PCT-A	S-14065
LAW-HPVR-06-Q-PCT-B	S-14017	LAW-HPVR-19-Q-PCT-B	S-14066
LAW-HPVR-06-Q-PCT-C	S-14018	LAW-HPVR-19-Q-PCT-C	S-14067
LAW-HPVR-07-Q-PCT-A	S-14019	LAW-HPVR-20-Q-PCT-A	S-14068
LAW-HPVR-07-Q-PCT-B	S-14020	LAW-HPVR-20-Q-PCT-B	S-14069
LAW-HPVR-07-Q-PCT-C	S-14021	LAW-HPVR-20-Q-PCT-C	S-14070
LAW-HPVR-08-Q-PCT-A	S-14022	LRM-STD-PCT-A	S-14071
LAW-HPVR-08-Q-PCT-B	S-14023	LRM-STD-PCT-B	S-14072
LAW-HPVR-08-Q-PCT-C	S-14024	LRM-STD-PCT-C	S-14073
LAW-HPVR-09-Q-PCT-A	S-14025	MQ WATER BLK-PCT-A	S-14074
LAW-HPVR-09-Q-PCT-B	S-14026	MQ WATER BLK-PCT-B	S-14075
LAW-HPVR-09-Q-PCT-C	S-14027	LAW-HPVR-21-Q-PCT-A	S-14076
LAW-HPVR-10-Q-PCT-A	S-14028	LAW-HPVR-21-Q-PCT-B	S-14077
LAW-HPVR-10-Q-PCT-B	S-14029	LAW-HPVR-21-Q-PCT-C	S-14078
LAW-HPVR-10-Q-PCT-C	S-14030	LAW-HPVR-22-Q-PCT-A	S-14079
LRM-STD-PCT-A	S-14031	LAW-HPVR-22-Q-PCT-B	S-14080
LRM-STD-PCT-B	S-14032	LAW-HPVR-22-Q-PCT-C	S-14081
LRM-STD-PCT-C	S-14033	LAW-HPVR-23-Q-PCT-A	S-14082
MQ WATER BLK-PCT-A	S-14034	LAW-HPVR-23-Q-PCT-B	S-14083
MQ WATER BLK-PCT-B	S-14035	LAW-HPVR-23-Q-PCT-C	S-14084
LAW-HPVR-11-Q-PCT-A	S-14036	LAW-HPVR-24-Q-PCT-A	S-14085
LAW-HPVR-11-Q-PCT-B	S-14037	LAW-HPVR-24-Q-PCT-B	S-14086
LAW-HPVR-11-Q-PCT-C	S-14038	LAW-HPVR-24-Q-PCT-C	S-14087
LAW-HPVR-12-Q-PCT-A	S-14039	LAW-HPVR-25-Q-PCT-A	S-14088
LAW-HPVR-12-Q-PCT-B	S-14040	LAW-HPVR-25-Q-PCT-B	S-14089
LAW-HPVR-12-Q-PCT-C	S-14041	LAW-HPVR-25-Q-PCT-C	S-14090
LAW-HPVR-13-Q-PCT-A	S-14042	LRM-STD-PCT-A	S-14091
LAW-HPVR-13-Q-PCT-B	S-14043	LRM-STD-PCT-B	S-14092
LAW-HPVR-13-Q-PCT-C	S-14044	LRM-STD-PCT-C	S-14093

Table 2-1. Identifiers for the PCT Leachates (continued)

PNNL Solution ID	Lab ID	PNNL Solution ID	Lab ID
MQ WATER BLK-PCT-A	S-14094	LAW-HPVR-11-CCC-PCT-A	S-14411
MQ WATER BLK-PCT-B	S-14095	LAW-HPVR-11-CCC-PCT-B	S-14412
LAW-HPVR-26-Q-PCT-A	S-14096	LAW-HPVR-11-CCC-PCT-C	S-14413
LAW-HPVR-26-Q-PCT-B	S-14097	LAW-HPVR-12-CCC-PCT-A	S-14414
LAW-HPVR-26-Q-PCT-C	S-14098	LAW-HPVR-12-CCC-PCT-B	S-14415
LRM-STD-PCT-A	S-14099	LAW-HPVR-12-CCC-PCT-C	S-14416
LRM-STD-PCT-B	S-14100	LAW-HPVR-13-CCC-PCT-A	S-14417
LRM-STD-PCT-C	S-14101	LAW-HPVR-13-CCC-PCT-B	S-14418
MQ WATER BLK-PCT-A	S-14102	LAW-HPVR-13-CCC-PCT-C	S-14419
MQ WATER BLK-PCT-B	S-14103	LAW-HPVR-14-CCC-PCT-A	S-14420
LAW-HPVR-01-1-CCC-PCT-A	S-14371	LAW-HPVR-14-CCC-PCT-B	S-14421
LAW-HPVR-01-1-CCC-PCT-B	S-14372	LAW-HPVR-14-CCC-PCT-C	S-14422
LAW-HPVR-01-1-CCC-PCT-C	S-14373	LAW-HPVR-15-CCC-PCT-A	S-14423
LAW-HPVR-02-1-CCC-PCT-A	S-14374	LAW-HPVR-15-CCC-PCT-B	S-14424
LAW-HPVR-02-1-CCC-PCT-B	S-14375	LAW-HPVR-15-CCC-PCT-C	S-14425
LAW-HPVR-02-1-CCC-PCT-C	S-14376	LRM-STD-PCT-A	S-14426
LAW-HPVR-03-1-CCC-PCT-A	S-14377	LRM-STD-PCT-B	S-14427
LAW-HPVR-03-1-CCC-PCT-B	S-14378	LRM-STD-PCT-C	S-14428
LAW-HPVR-03-1-CCC-PCT-C	S-14379	MQ WATER BLK-PCT-A	S-14429
LAW-HPVR-04-1-CCC-PCT-A	S-14380	MQ WATER BLK-PCT-B	S-14430
LAW-HPVR-04-1-CCC-PCT-B	S-14381	LAW-HPVR-16-CCC-PCT-A	S-14431
LAW-HPVR-04-1-CCC-PCT-C	S-14382	LAW-HPVR-16-CCC-PCT-B	S-14432
LAW-HPVR-05-CCC-PCT-A	S-14383	LAW-HPVR-16-CCC-PCT-C	S-14433
LAW-HPVR-05-CCC-PCT-B	S-14384	LAW-HPVR-17-CCC-PCT-A	S-14434
LAW-HPVR-05-CCC-PCT-C	S-14385	LAW-HPVR-17-CCC-PCT-B	S-14435
LRM-STD-PCT-A	S-14386	LAW-HPVR-17-CCC-PCT-C	S-14436
LRM-STD-PCT-B	S-14387	LAW-HPVR-18-CCC-PCT-A	S-14437
LRM-STD-PCT-C	S-14388	LAW-HPVR-18-CCC-PCT-B	S-14438
MQ WATER BLK-PCT-A	S-14389	LAW-HPVR-18-CCC-PCT-C	S-14439
MQ WATER BLK-PCT-B	S-14390	LAW-HPVR-19-CCC-PCT-A	S-14440
LAW-HPVR-06-CCC-PCT-A	S-14391	LAW-HPVR-19-CCC-PCT-B	S-14441
LAW-HPVR-06-CCC-PCT-B	S-14392	LAW-HPVR-19-CCC-PCT-C	S-14442
LAW-HPVR-06-CCC-PCT-C	S-14393	LAW-HPVR-23-CCC-PCT-A	S-14443
LAW-HPVR-07-CCC-PCT-A	S-14394	LAW-HPVR-23-CCC-PCT-B	S-14444
LAW-HPVR-07-CCC-PCT-B	S-14395	LAW-HPVR-23-CCC-PCT-C	S-14445
LAW-HPVR-07-CCC-PCT-C	S-14396	LRM-STD-PCT-A	S-14446
LAW-HPVR-08-CCC-PCT-A	S-14397	LRM-STD-PCT-B	S-14447
LAW-HPVR-08-CCC-PCT-B	S-14398	LRM-STD-PCT-C	S-14448
LAW-HPVR-08-CCC-PCT-C	S-14399	MQ WATER BLK-PCT-A	S-14449
LAW-HPVR-09-CCC-PCT-A	S-14400	MQ WATER BLK-PCT-B	S-14450
LAW-HPVR-09-CCC-PCT-B	S-14401	LAW-HPVR-20-CCC-PCT-A	S-14451
LAW-HPVR-09-CCC-PCT-C	S-14402	LAW-HPVR-20-CCC-PCT-B	S-14452
LAW-HPVR-10-CCC-PCT-A	S-14403	LAW-HPVR-20-CCC-PCT-C	S-14453
LAW-HPVR-10-CCC-PCT-B	S-14404	LAW-HPVR-21-CCC-PCT-A	S-14454
LAW-HPVR-10-CCC-PCT-C	S-14405	LAW-HPVR-21-CCC-PCT-B	S-14455
LRM-STD-PCT-A	S-14406	LAW-HPVR-21-CCC-PCT-C	S-14456
LRM-STD-PCT-B	S-14407	LAW-HPVR-22-CCC-PCT-A	S-14457
LRM-STD-PCT-C	S-14408	LAW-HPVR-22-CCC-PCT-B	S-14458
MQ WATER BLK-PCT-A	S-14409	LAW-HPVR-22-CCC-PCT-C	S-14459
MQ WATER BLK-PCT-B	S-14410	LAW-HPVR-24-CCC-PCT-A	S-14460

Table 2-1. Identifiers for the PCT Leachates (continued)

PNNL Solution ID	Lab ID	PNNL Solution ID	Lab ID
LAW-HPVR-24-CCC-PCT-B	S-14461	LAW-HPVR-11-Q-PCT-C-1	S-15350
LAW-HPVR-24-CCC-PCT-C	S-14462	LAW-HPVR-12-Q-PCT-A-1	S-15351
LAW-HPVR-25-CCC-PCT-A	S-14463	LAW-HPVR-12-Q-PCT-B-1	S-15352
LAW-HPVR-25-CCC-PCT-B	S-14464	LAW-HPVR-12-Q-PCT-C-1	S-15353
LAW-HPVR-25-CCC-PCT-C	S-14465	LAW-HPVR-13-Q-PCT-A-1	S-15354
LAW-HPVR-26-CCC-PCT-A	S-14466	LAW-HPVR-13-Q-PCT-B-1	S-15355
LAW-HPVR-26-CCC-PCT-B	S-14467	LAW-HPVR-13-Q-PCT-C-1	S-15356
LAW-HPVR-26-CCC-PCT-C	S-14468	LAW-HPVR-15-Q-PCT-A-1	S-15357
LRM-STD-PCT-1-A	S-14469	LAW-HPVR-15-Q-PCT-B-1	S-15358
LRM-STD-PCT-1-B	S-14470	LAW-HPVR-15-Q-PCT-C-1	S-15359
LRM-STD-PCT-1-C	S-14471	STD-ARM-PCT-A-2	S-15360
MQ WATER BLK-PCT-1-A	S-14472	STD-ARM-PCT-B-2	S-15361
MQ WATER BLK-PCT-1-B	S-14473	STD-ARM-PCT-C-2	S-15362
LAW-HPVR-06-CCC-PCT-A-1	S-15325	MQ-WATER-BLK-PCT-A-2	S-15363
LAW-HPVR-06-CCC-PCT-B-1	S-15326	MQ-WATER-BLK-PCT-B-2	S-15364
LAW-HPVR-06-CCC-PCT-C-1	S-15327	LAW-HPVR-01-1-Q-PCT-A-1	S-15365
LAW-HPVR-07-CCC-PCT-A-1	S-15328	LAW-HPVR-01-1-Q-PCT-B-1	S-15366
LAW-HPVR-07-CCC-PCT-B-1	S-15329	LAW-HPVR-01-1-Q-PCT-C-1	S-15367
LAW-HPVR-07-CCC-PCT-C-1	S-15330	LAW-HPVR-03-1-Q-PCT-A-1	S-15368
LAW-HPVR-08-CCC-PCT-A-1	S-15331	LAW-HPVR-03-1-Q-PCT-B-1	S-15369
LAW-HPVR-08-CCC-PCT-B-1	S-15332	LAW-HPVR-03-1-Q-PCT-C-1	S-15370
LAW-HPVR-08-CCC-PCT-C-1	S-15333	LAW-HPVR-04-1-Q-PCT-A-1	S-15371
LAW-HPVR-09-CCC-PCT-A-1	S-15334	LAW-HPVR-04-1-Q-PCT-B-1	S-15372
LAW-HPVR-09-CCC-PCT-B-1	S-15335	LAW-HPVR-04-1-Q-PCT-C-1	S-15373
LAW-HPVR-09-CCC-PCT-C-1	S-15336	LAW-HPVR-05-Q-PCT-A-1	S-15374
LAW-HPVR-10-CCC-PCT-A-1	S-15337	LAW-HPVR-05-Q-PCT-B-1	S-15375
LAW-HPVR-10-CCC-PCT-B-1	S-15338	LAW-HPVR-05-Q-PCT-C-1	S-15376
LAW-HPVR-10-CCC-PCT-C-1	S-15339	LAW-HPVR-14-Q-PCT-A-1	S-15377
STD-ARM-PCT-A-1	S-15340	LAW-HPVR-14-Q-PCT-B-1	S-15378
STD-ARM-PCT-B-1	S-15341	LAW-HPVR-14-Q-PCT-C-1	S-15379
STD-ARM-PCT-C-1	S-15342	LAW-HPVR-26-Q-PCT-A-1	S-15380
MQ-WATER-BLK-PCT-A-1	S-15343	LAW-HPVR-26-Q-PCT-B-1	S-15381
MQ-WATER-BLK-PCT-B-1	S-15344	LAW-HPVR-26-Q-PCT-C-1	S-15382
LAW-HPVR-02-1-Q-PCT-A-1	S-15345	STD-ARM-PCT-A-3	S-15383
LAW-HPVR-02-1-Q-PCT-B-1	S-15346	STD-ARM-PCT-B-3	S-15384
LAW-HPVR-02-1-Q-PCT-C-1	S-15347	STD-ARM-PCT-C-3	S-15385
LAW-HPVR-11-Q-PCT-A-1	S-15348	MQ-WATER-BLK-PCT-A-3	S-15386
LAW-HPVR-11-Q-PCT-B-1	S-15349	MQ-WATER-BLK-PCT-B-3	S-15387

2.3 PCT Leachate Analysis

The PCT leachate samples were analyzed by inductively coupled plasma – optical emission spectroscopy (ICP-OES)[7] according to three analytical study plans designed to statistically randomize the measurements.[8-10] High purity multi-element custom ICP solution standards[c] (std) were prepared at SRNL and included in the analytical study plan as a check of the accuracy of the instrument used for these measurements. The analytical measurements were adjusted based on the dilution provided by PNNL. Normalized elemental release values were calculated for each glass based on the target and measured[11] glass compositions.

[c] ICP multi-element custom solution, product number SM-744-013, High Purity Standards, North Charleston, SC.

3.0 Results and Discussion

JMP® version 16.0.0 (SAS Institute, Inc.)[12] was used to support these analyses.

3.1 Measured Compositions of the PCT Leachates

Table A-1, Table A-2, and Table A-3 in Appendix A list the elemental concentration, in mg/L, for the LAW HPVR PCT leachates, blanks, and multi-element custom standard solutions as measured by ICP-OES in analytical sequence. Table A-1, Table A-2, and Table A-3 in Appendix A provide the measurements after dilution correction, using a dilution factor (DF) of 5, provided by PNNL.

The measured concentrations of the analytes in most of the blank solutions included with the PCT were below detection limits (BDL), which was 1 mg/L for this testing, and are denoted by a less than symbol (<). However, ten test blanks had K, Na, and/or Si concentrations above the detection limit. The ten test blank solutions with reportable K, Na, and Si concentrations greater than the detection limit are collected from Appendix A and reproduced in Table 3-1.

Table 3-1. Test Blanks with Measured K, Na, and/or Si Concentrations (mg/L)

PNNL Solution ID	Lab ID	K ar*	Na ar*	Si ar*	K+	Na+	Si+
MQ WATER BLK-PCT-B	S-14015	1.17	<1.00	<1.00	5.85	<5.00	<5.00
MQ WATER BLK-PCT-A	S-14034	1.79	<1.00	2.08	8.95	<5.00	10.4
MQ WATER BLK-PCT-B	S-14035	1.85	1.25	1.38	9.25	6.25	6.90
MQ WATER BLK-PCT-A	S-14054	<1.00	<1.00	1.81	<5.00	<5.00	9.05
MQ WATER BLK-PCT-B	S-14055	<1.00	<1.00	1.34	<5.00	<5.00	6.70
MQ WATER BLK-PCT-A	S-14074	1.40	<1.00	<1.00	7.00	<5.00	<5.00
MQ WATER BLK-PCT-B	S-14075	1.39	1.07	<1.00	6.95	5.35	<5.00
MQ WATER BLK-PCT-B	S-14103	1.41	<1.00	1.00	7.05	<5.00	5.00
MQ WATER BLK-PCT-A	S-14389	<1.00	1.22	<1.00	<5.00	6.10	<5.00
MQ WATER BLK-PCT-1-A	S-14472	<1.00	1.05	<1.00	<5.00	5.25	<5.00

* Measurements as received from the analytical lab
+ Dilution-corrected measurements using the DF of 5

Table A-4 in Appendix A lists the measured elemental concentrations in the leachates from the low-activity reference material (LRM) glass included in the PCT. The measured B and Si concentrations were generally in agreement with published LRM leachate value ranges[13]. With the exception of 3 leachates, the measured Na concentrations were greater than the published average value for 30 leachates, and of those, 13 had a Na concentration greater than the published range. The measured B concentration in one LRM leachate was also lower than the expected based on the published ranges. These LRM leachates with measured elemental concentrations outside the published ranges are shaded gray in Table A-4.

Table A-5 in Appendix A lists the measured elemental concentrations in the leachates from the Approved Reference Material (ARM-1) glass included in the PCT. The measured analyte concentrations (mg/L) were generally in agreement based on published ARM behavior[14], with the following exceptions: The measured Na concentrations were higher than expected in two ARM leachates, one of which also had a Si concentration higher than expected. These ARM leachates with measured elemental concentrations outside the published ranges are shaded gray in Table A-5.

Following the guidance in ASTM C1285,[6] the mean, standard deviation, and percent relative standard deviation (%RSD) were determined for six elements (Al, B, Li, K, Na, and Si) measured in the multi-element solution standard for each analytical block. As shown in Table A-6 in Appendix A, the mean measured concentration for each analytical block was found to be less than 10% from the reference value (i.e., a percent relative bias less than 10%), and the %RSD was less than 10% for each of the measured elements. The analytical results are acceptable per the criteria in ASTM C1285, which indicates no significant issues with the analytical outcomes from the measurements of the PCT leachates.

Exhibit A-1 in Appendix A provides linear plots of the triplicate leachate concentrations by the glass ID by PNNL grouping. Plotting the data in this format allows for the assessment of the repeatability of the measurements for each glass.

3.2 Normalization of PCT Data

Elemental release as measured by the PCT was computed as normalized concentration (NC_i) for B, Li, Na, and Si for each of the test glasses following the expression given in ASTM C1285,[6]

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

where NC_i is the normalized concentration in units of $g_{waste\ form}/L_{leachant}$, $c_i(sample)$ is the concentration of element "*i*" in the leachate in units of g_i/L (corrected for the dilutions performed at PNNL), and f_i is the mass fraction of element "*i*" in the unleached glass in units of g_i/g_{glass}.[d] NC_i was computed using both the targeted and average measured compositions.[11]

NC_i values were calculated using the units of measurement provided with the analytical results for this study. To accommodate the triplicate leachate measurements for each of the study glasses, the common logarithm of the normalized concentration for each element "*i*" (NC_i) for each of the study glasses was determined using the equation:

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

where NC_i remains in units of $g_{waste\ form}/L_{leachant}$, $\overline{\log_{10} c_i}$ is the average of the common logarithms of the measured concentrations of element "*i*" in the triplicate leachates in units of mg/L (corrected for the dilutions performed at PNNL as discussed in Section 3.1), and $\log_{10} f_i$ is either the common logarithm of the targeted concentration of element "*i*" in the glass in units of weight percent (wt.%) or the common logarithm of the average measured concentration of element "*i*" in the glass in units of wt.% (reported previously[11]). Note that the symbols in this second equation were kept consistent with those used in ASTM C1285,[6] but the units of measurement differ.

Table B-1 in Appendix B provides the normalized PCT responses for the Q and CCC versions for each of the study glasses as well as the responses for the LRM and ARM-1 reference glasses. The results are grouped by Glass ID. Note that a less than symbol (<) is provided as part of this table to show results involving BDL values. The plots of Exhibit B-1 in Appendix B provide a graphical comparison between the PCT responses for the three sets of study glasses.

A review of the PCT data resulted in the following observations:

- The measured glass compositions for the study glasses[11] were close to target values; therefore, little difference (≤13%) was seen when evaluating the normalized release using the targeted or measured glass compositions.
- In most cases, heat treatment had marginal impact on the NC_i values. In the eight following cases, the Q NC_i values were higher than the CCC:

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

    - LAW-HPVR-04-1-Q, LAW-HPVR-05-Q, LAW-HPVR-06-Q, LAW-HPVR-07-Q, LAW-HPVR-09-Q, LAW-HPVR-10-Q, LAW-HPVR-20-Q and LAW-HPVR-24-Q NC_B, NC_{Li}, NC_{Na}, and NC_{Si} values were higher than the CCC values.
- In one case, LAW-HPVR-25, the heat treated NC_B, NC_{Li}, and NC_{Na} values were higher than the Q values.
- For most of the glasses, both CCC and Q versions exceeded the WTP NC_B, NC_{Na}, and/or NC_{Si} 4 g/L constraints.[e]
    - LAW-HPVR-01-1, LAW-HPVR-02-1, LAW-HPVR-04-1, LAW-HPVR-05, LAW-HPVR-10, LAW-HPVR-11, LAW-HPVR-15, LAW-HPVR-18, LAW-HPVR-24, and LAW-HPVR-25 exceeded NC_B and NC_{Na} constraints.
    - LAW-HPVR-09 and LAW-HPVR-20 exceeded all constraints.
- The following glasses also exceeded WTP constraints:
    - LAW-HPVR-10-Q exceeded all constraints.
    - LAW-HPVR-06-Q, LAW-HPVR-07-CCC, and LAW-HPVR-14-CCC exceeded NC_{Na} constraints.
    - LAW-HPVR-07-Q, LAW-HPVR-13-Q, and LAW-HPVR-14-Q exceeded NC_B and NC_{Na} constraints.
    - LAW-HPVR-21-Q exceeded NC_B constraints.

4.0 Summary

The elemental release for the study glasses is reported as normalized concentration (NC_i). NC_i of several elements was computed for both the target and measured glass compositions, which were similar, resulting in no significant differences when computing the NC_i values. The majority of the glasses exhibited NC_B, NC_{Na}, and NC_{Si} values that were greater than the Hanford Tank Waste Treatment Plant (WTP) low-activity waste constraint of 4 g/L. Several blank solutions included with the study glasses had K, Na, and Si concentrations above the analytical detection limit. Additionally, several of the reference glasses that were included with the study glasses had Na concentrations that were higher than expected. The unexpected analyte concentrations in the reference glass and blank solutions were insignificant with respect to the reported NC_i values, and are noted for completeness and their experimental relevance.

[e] Contract DE-AC27-01RV14136, as amended, U.S. Department of Energy, Richland, WA (2000).

5.0 References

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13. W.L. Ebert and S.F. Wolf, "Round-Robin Testing of a Reference Glass for Low-Activity Waste Forms," Argonne National Laboratory, Argonne, IL, ANL-99/22, Revision 0, 1999.

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Appendix A. Tables Containing the Measurement Data for the LAW HPVR PCT Leachates

Table A-1. Quenched Glass PCT Leachate Measurements (mg/L) Measured by ICP-OES

PNNL Solution ID	Block	Seq.	Lab ID	Al	B	Cr	K	Li	Na	Si	Zr
std-1	1	1	std-11	3.72	18.2	<1.00	9.61	9.98	81.5	47.0	<1.00
LAW-HPVR-23-Q-PCT-C	1	2	S-14084	<5.00	71.1	<5.00	22.7	10.3	609	202	<5.00
LAW-HPVR-11-Q-PCT-C	1	3	S-14038	<5.00	495	<5.00	251	27.5	2000	367	<5.00
LRM-STD-PCT-B	1	4	S-14072	15.9	28.4	<5.00	<5.00	<5.00	174	84.0	<5.00
MQ WATER BLK-PCT-A	1	5	S-14094	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
LAW-HPVR-25-Q-PCT-A	1	6	S-14088	<5.00	114	<5.00	56.1	10.7	1033	340	<5.00
std-1	1	7	std-12	4.38	19.9	<1.00	9.88	10.1	83.4	51.4	<1.00
MQ WATER BLK-PCT-A	1	8	S-14014	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
LAW-HPVR-26-Q-PCT-B	1	9	S-14097	26.3	90.8	<5.00	27.3	31.8	286	68.8	<5.00
LAW-HPVR-21-Q-PCT-A	1	10	S-14076	18.0	165	<5.00	111	<5.00	560	83.2	<5.00
LAW-HPVR-09-Q-PCT-A	1	11	S-14025	<5.00	1075	9.90	156	311	3045	975	<5.00
LRM-STD-PCT-C	1	12	S-14093	14.7	27.0	<5.00	<5.00	<5.00	166	81.3	<5.00
std-1	1	13	std-13	4.03	18.9	<1.00	10.1	10.3	83.7	49.0	<1.00
LAW-HPVR-01-1-Q-PCT-A	1	14	S-13996	<5.00	510	<5.00	134	153	1628	467	<5.00
LAW-HPVR-22-Q-PCT-B	1	15	S-14080	8.66	38.0	<5.00	24.9	10.5	309	93.2	<5.00
LAW-HPVR-03-1-Q-PCT-C	1	16	S-14004	12.5	35.7	<5.00	38.1	18.6	188	60.0	<5.00
MQ WATER BLK-PCT-A	1	17	S-14054	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	9.07	<5.00
LAW-HPVR-17-Q-PCT-A	1	18	S-14059	8.19	59.5	<5.00	46.3	11.2	231	73.5	<5.00
LAW-HPVR-18-Q-PCT-B	1	19	S-14063	<5.00	363	<5.00	41.6	122	1109	326	<5.00
std-1	1	20	std-14	4.09	19.8	<1.00	9.47	10.1	83.6	50.4	<1.00
LAW-HPVR-02-1-Q-PCT-B	1	21	S-14000	<5.00	367	<5.00	186	7.00	1230	304	<5.00
LAW-HPVR-06-Q-PCT-B	1	22	S-14017	<5.00	145	<5.00	155	24.4	490	202	<5.00
LAW-HPVR-07-Q-PCT-C	1	23	S-14021	<5.00	91.6	<5.00	96.4	22.3	779	221	<5.00
LAW-HPVR-19-Q-PCT-C	1	24	S-14067	<5.00	48.3	<5.00	<5.00	16.3	418	173	<5.00
LRM-STD-PCT-C	1	25	S-14013	14.3	26.8	<5.00	<5.00	<5.00	178	78.9	<5.00
LAW-HPVR-15-Q-PCT-C	1	26	S-14050	<5.00	217	<5.00	162	95.5	658	450	<5.00
std-1	1	27	std-15	3.83	18.9	<1.00	9.30	9.49	78.6	48.2	<1.00
LAW-HPVR-10-Q-PCT-B	1	28	S-14029	<5.00	610	<5.00	209	26.1	2725	731	<5.00
LAW-HPVR-05-Q-PCT-A	1	29	S-14008	<5.00	444	6.16	25.1	239	1393	610	<5.00
LRM-STD-PCT-A	1	30	S-14051	10.7	18.7	<5.00	<5.00	<5.00	155	70.3	<5.00
LAW-HPVR-14-Q-PCT-B	1	31	S-14046	7.74	140	<5.00	<5.00	<5.00	838	175	<5.00
LAW-HPVR-13-Q-PCT-A	1	32	S-14042	<5.00	100	<5.00	78.4	44.0	588	371	<5.00
std-1	1	33	std-16	3.73	18.4	<1.00	9.64	10.2	83.9	47.7	<1.00
std-2	2	1	std-21	4.07	19.4	<1.00	10.5	10.1	84.7	48.8	<1.00
LAW-HPVR-22-Q-PCT-C	2	2	S-14081	9.80	44.2	<5.00	35.6	11.1	324	100	<5.00
LAW-HPVR-10-Q-PCT-C	2	3	S-14030	<5.00	782	<5.00	226	27.5	3235	860	<5.00
MQ WATER BLK-PCT-B	2	4	S-14095	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
LAW-HPVR-18-Q-PCT-C	2	5	S-14064	<5.00	375	<5.00	36.6	121	1062	325	<5.00
LRM-STD-PCT-B	2	6	S-14052	12.0	21.1	<5.00	6.64	<5.00	160	79.5	<5.00
std-2	2	7	std-22	3.74	18.7	<1.00	9.99	9.54	77.1	46.6	<1.00
MQ WATER BLK-PCT-B	2	8	S-14055	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	6.68	<5.00
LAW-HPVR-16-Q-PCT-A	2	9	S-14056	5.04	128	<5.00	40.4	14.8	458	110	<5.00
LAW-HPVR-01-1-Q-PCT-B	2	10	S-13997	<5.00	535	<5.00	134	159	1655	494	<5.00
LRM-STD-PCT-A	2	11	S-14099	14.9	28.0	<5.00	9.25	<5.00	180	82.5	<5.00
LAW-HPVR-21-Q-PCT-B	2	12	S-14077	18.1	166	<5.00	101	<5.00	542	83.8	<5.00
std-2	2	13	std-23	4.17	19.7	<1.00	10.7	9.91	81.7	49.7	<1.00
LAW-HPVR-09-Q-PCT-B	2	14	S-14026	<5.00	1067	9.18	148	297	2967	1002	<5.00
LRM-STD-PCT-C	2	15	S-14073	15.7	30.1	<5.00	5.17	<5.00	186	84.8	<5.00

Table A-1. Quenched Glass PCT Leachate Measurements (mg/L) Measured by ICP-OES (continued)

PNNL Solution ID	Block	Seq.	Lab ID	Al	B	Cr	K	Li	Na	Si	Zr
LAW-HPVR-06-Q-PCT-C	2	16	S-14018	<5.00	147	<5.00	154	23.0	473	202	<5.00
MQ WATER BLK-PCT-B	2	17	S-14015	<5.00	<5.00	<5.00	5.85	<5.00	<5.00	<5.00	<5.00
LAW-HPVR-20-Q-PCT-A	2	18	S-14068	<5.00	2036	38.9	6.83	42.1	8500	2225	<5.00
LAW-HPVR-26-Q-PCT-C	2	19	S-14098	25.4	93.6	<5.00	26.9	30.3	282	69.6	<5.00
std-2	2	20	std-24	4.20	19.9	<1.00	10.4	9.85	80.6	49.9	<1.00
LAW-HPVR-24-Q-PCT-A	2	21	S-14085	<5.00	284	<5.00	363	158	1395	659	<5.00
LAW-HPVR-17-Q-PCT-B	2	22	S-14060	9.32	60.4	<5.00	50.2	10.8	231	73.4	<5.00
LAW-HPVR-12-Q-PCT-A	2	23	S-14039	<5.00	45.4	<5.00	6.03	16.1	625	282	<5.00
LAW-HPVR-05-Q-PCT-B	2	24	S-14009	<5.00	479	6.55	29.9	240	1546	643	<5.00
LAW-HPVR-02-1-Q-PCT-C	2	25	S-14001	<5.00	379	<5.00	176	6.33	1220	311	<5.00
LAW-HPVR-13-Q-PCT-B	2	26	S-14043	<5.00	103	<5.00	72.8	40.1	532	371	<5.00
std-2	2	27	std-25	4.35	19.8	<1.00	9.96	10.2	83.1	50.2	<1.00
LAW-HPVR-14-Q-PCT-C	2	28	S-14047	9.16	154	<5.00	7.15	<5.00	946	187	<5.00
LAW-HPVR-25-Q-PCT-B	2	29	S-14089	<5.00	117	5.18	59.3	10.5	1084	341	<5.00
LRM-STD-PCT-A	2	30	S-14031	14.3	23.9	<5.00	5.49	<5.00	173	85.1	<5.00
LAW-HPVR-04-1-Q-PCT-A	2	31	S-14005	<5.00	411	13.2	97.6	237	1831	888	<5.00
LAW-HPVR-08-Q-PCT-A	2	32	S-14022	15.9	82.2	<5.00	28.1	29.6	244	64.6	<5.00
std-2	2	33	std-26	4.22	19.4	<1.00	9.53	9.93	82.1	49.1	<1.00
std-3	3	1	std-31	4.03	19.4	<1.00	10.6	10.1	84.2	48.4	<1.00
LAW-HPVR-23-Q-PCT-A	3	2	S-14082	<5.00	76.9	<5.00	23.6	9.81	661	215	<5.00
LAW-HPVR-15-Q-PCT-A	3	3	S-14048	<5.00	205	<5.00	161	77.6	732	424	<5.00
MQ WATER BLK-PCT-A	3	4	S-14074	<5.00	<5.00	<5.00	7.00	<5.00	<5.00	<5.00	<5.00
LRM-STD-PCT-A	3	5	S-14091	14.7	26.6	<5.00	9.13	<5.00	169	74.4	<5.00
LAW-HPVR-08-Q-PCT-B	3	6	S-14023	14.4	80.4	<5.00	27.7	30.1	240	58.8	<5.00
std-3	3	7	std-32	3.85	18.8	<1.00	9.88	9.98	82.3	46.7	<1.00
MQ WATER BLK-PCT-A	3	8	S-14034	<5.00	<5.00	<5.00	8.96	<5.00	<5.00	10.4	<5.00
LRM-STD-PCT-B	3	9	S-14032	13.4	25.5	<5.00	10.5	<5.00	168	78.4	<5.00
LAW-HPVR-13-Q-PCT-C	3	10	S-14044	<5.00	101	<5.00	82.3	44.6	570	362	<5.00
MQ WATER BLK-PCT-A	3	11	S-14102	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
LAW-HPVR-21-Q-PCT-C	3	12	S-14078	16.4	155	<5.00	96.0	<5.00	530	76.8	<5.00
std-3	3	13	std-33	3.88	19.1	<1.00	9.51	9.75	80.5	47.1	<1.00
LAW-HPVR-01-1-Q-PCT-C	3	14	S-13998	<5.00	570	<5.00	145	169	1664	484	<5.00
LRM-STD-PCT-C	3	15	S-14053	12.5	23.4	<5.00	9.20	<5.00	161	77.4	<5.00
LAW-HPVR-25-Q-PCT-C	3	16	S-14090	<5.00	111	6.69	52.9	9.47	1032	322	<5.00
LAW-HPVR-07-Q-PCT-A	3	17	S-14019	<5.00	102	<5.00	96.1	21.0	791	239	<5.00
LAW-HPVR-04-1-Q-PCT-B	3	18	S-14006	<5.00	423	15.1	97.8	235	1650	796	<5.00
LAW-HPVR-24-Q-PCT-B	3	19	S-14086	<5.00	288	<5.00	374	162	1340	622	<5.00
std-3	3	20	std-34	3.77	19.4	<1.00	9.69	9.72	81.5	45.7	<1.00
LRM-STD-PCT-A	3	21	S-14011	14.4	28.7	<5.00	7.08	<5.00	168	77.7	<5.00
LAW-HPVR-05-Q-PCT-C	3	22	S-14010	<5.00	455	8.20	33.8	233	1506	647	<5.00
LAW-HPVR-03-1-Q-PCT-A	3	23	S-14002	13.4	41.4	<5.00	46.2	20.4	210	61.7	<5.00
LAW-HPVR-20-Q-PCT-B	3	24	S-14069	<5.00	1828	37.4	9.20	41.7	8850	1976	<5.00
LAW-HPVR-16-Q-PCT-B	3	25	S-14057	5.02	131	<5.00	32.8	14.4	446	108	<5.00
LAW-HPVR-17-Q-PCT-C	3	26	S-14061	8.93	61.0	<5.00	46.2	10.8	225	68.7	<5.00
std-3	3	27	std-35	4.00	20.5	<1.00	9.78	9.92	82.3	48.5	<1.00
LAW-HPVR-12-Q-PCT-B	3	28	S-14040	<5.00	44.7	<5.00	11.3	16.5	615	282	<5.00
LAW-HPVR-19-Q-PCT-A	3	29	S-14065	<5.00	51.2	<5.00	11.5	14.6	389	172	<5.00
LAW-HPVR-11-Q-PCT-A	3	30	S-14036	<5.00	450	5.17	233	25.0	2007	324	<5.00

Table A-1. Quenched Glass PCT Leachate Measurements (mg/L) Measured by ICP-OES (continued)

PNNL Solution ID	Block	Seq.	Lab ID	Al	B	Cr	K	Li	Na	Si	Zr
LRM-STD-PCT-B	3	31	S-14100	15.7	31.6	<5.00	12.6	<5.00	184	80.7	<5.00
LAW-HPVR-09-Q-PCT-C	3	32	S-14027	<5.00	1122	11.4	151	291	3140	945	<5.00
std-3	3	33	std-36	3.99	20.5	<1.00	9.31	9.64	82.2	50.5	<1.00
std-4	4	1	std-41	4.00	19.3	<1.00	9.85	10.4	82.7	48.7	<1.00
LAW-HPVR-14-Q-PCT-A	4	2	S-14045	8.06	147	<5.00	<5.00	<5.00	951	178	<5.00
LRM-STD-PCT-C	4	3	S-14033	13.2	23.0	<5.00	<5.00	<5.00	166	77.8	<5.00
LAW-HPVR-26-Q-PCT-A	4	4	S-14096	24.3	91.6	<5.00	27.7	34.6	296	65.2	<5.00
LAW-HPVR-18-Q-PCT-A	4	5	S-14062	<5.00	381	<5.00	44.5	133	1109	328	<5.00
LAW-HPVR-12-Q-PCT-C	4	6	S-14041	<5.00	42.8	<5.00	5.35	16.8	574	266	<5.00
std-4	4	7	std-42	4.05	19.6	<1.00	9.96	10.5	84.7	49.5	<1.00
LAW-HPVR-15-Q-PCT-B	4	8	S-14049	<5.00	211	<5.00	166	98.8	787	435	<5.00
LAW-HPVR-11-Q-PCT-B	4	9	S-14037	<5.00	496	<5.00	276	30.2	2022	359	<5.00
LAW-HPVR-04-1-Q-PCT-C	4	10	S-14007	<5.00	420	14.0	92.3	232	1665	825	<5.00
LAW-HPVR-20-Q-PCT-C	4	11	S-14070	<5.00	1990	37.5	5.84	43.8	8900	2102	<5.00
LRM-STD-PCT-B	4	12	S-14012	15.6	30.6	<5.00	6.26	<5.00	180	85.6	<5.00
std-4	4	13	std-43	4.05	20.6	<1.00	9.66	9.76	79.8	51.3	<1.00
LAW-HPVR-10-Q-PCT-A	4	14	S-14028	<5.00	710	<5.00	212	25.5	2978	824	<5.00
LAW-HPVR-24-Q-PCT-C	4	15	S-14087	<5.00	304	<5.00	362	147	1391	663	<5.00
LAW-HPVR-23-Q-PCT-B	4	16	S-14083	<5.00	75.6	<5.00	10.1	8.38	584	209	<5.00
LRM-STD-PCT-A	4	17	S-14071	14.9	31.7	<5.00	7.05	<5.00	184	87.2	<5.00
LAW-HPVR-16-Q-PCT-C	4	18	S-14058	5.25	138	<5.00	37.1	15.2	455	111	<5.00
LRM-STD-PCT-B	4	19	S-14092	14.1	27.5	<5.00	10.8	<5.00	164	78.8	<5.00
std-4	4	20	std-44	4.02	20.4	<1.00	9.29	9.75	81.6	50.5	<1.00
LAW-HPVR-07-Q-PCT-B	4	21	S-14020	<5.00	101	<5.00	94.3	20.3	871	230	<5.00
MQ WATER BLK-PCT-B	4	22	S-14035	<5.00	<5.00	<5.00	9.27	<5.00	6.27	6.90	<5.00
LAW-HPVR-02-1-Q-PCT-A	4	23	S-13999	<5.00	407	<5.00	195	7.65	1360	320	<5.00
LAW-HPVR-08-Q-PCT-C	4	24	S-14024	14.2	86.1	<5.00	26.1	30.4	249	65.7	<5.00
MQ WATER BLK-PCT-B	4	25	S-14103	<5.00	<5.00	<5.00	7.06	<5.00	<5.00	5.01	<5.00
LAW-HPVR-06-Q-PCT-A	4	26	S-14016	<5.00	167	<5.00	160	24.6	513	227	<5.00
std-4	4	27	std-45	3.89	19.8	<1.00	10.0	10.2	85.3	50.1	<1.00
LRM-STD-PCT-C	4	28	S-14101	15.5	31.9	<5.00	9.31	<5.00	189	83.1	<5.00
LAW-HPVR-22-Q-PCT-A	4	29	S-14079	9.92	44.8	<5.00	32.6	12.3	358	102	<5.00
LAW-HPVR-03-1-Q-PCT-B	4	30	S-14003	12.5	39.5	<5.00	35.0	18.6	196	61.7	<5.00
MQ WATER BLK-PCT-B	4	31	S-14075	<5.00	<5.00	<5.00	6.96	<5.00	5.37	<5.00	<5.00
LAW-HPVR-19-Q-PCT-B	4	32	S-14066	<5.00	51.9	<5.00	8.73	14.4	384	181	<5.00
std-4	4	33	std-46	3.74	19.7	<1.00	9.93	9.15	81.7	50.9	<1.00

Table A-2. CCC PCT Leachate Measurements (mg/L) Measured by ICP-OES

PNNL Solution ID	Block	Seq.	Lab ID	Al	B	Cr	K	Li	Na	Si	Zr
std-1	1	1	std-11	4.00	19.2	<1.00	10.0	9.74	80.6	48.7	<1.00
LRM-STD-PCT-B	1	2	S-14387	15.3	28.5	<5.00	<5.00	<5.00	177	79.5	<5.00
LAW-HPVR-12-CCC-PCT-B	1	3	S-14415	<5.00	35.0	<5.00	<5.00	17.3	469	227	<5.00
LAW-HPVR-23-CCC-PCT-A	1	4	S-14443	<5.00	55.0	<5.00	14.5	10.3	474	168	<5.00
LAW-HPVR-18-CCC-PCT-C	1	5	S-14439	<5.00	291	<5.00	31.4	95.0	795	277	<5.00
LAW-HPVR-26-CCC-PCT-B	1	6	S-14467	11.0	112	<5.00	31.0	40.6	289	84.5	<5.00
std-1	1	7	std-12	3.97	19.0	<1.00	9.67	9.67	80.1	48.6	<1.00
LAW-HPVR-08-CCC-PCT-C	1	8	S-14399	14.9	67.5	<5.00	24.6	26.1	200	53.5	<5.00
LAW-HPVR-17-CCC-PCT-B	1	9	S-14435	9.10	55.5	<5.00	41.2	12.1	197	60.0	<5.00
LAW-HPVR-11-CCC-PCT-A	1	10	S-14411	<5.00	395	<5.00	194	22.8	1515	315	<5.00
LAW-HPVR-20-CCC-PCT-A	1	11	S-14451	<5.00	1315	17.2	<5.00	30.2	5300	1525	<5.00
LAW-HPVR-21-CCC-PCT-B	1	12	S-14455	15.1	129	<5.00	75.5	<5.00	428	74.0	<5.00
std-1	1	13	std-13	3.88	18.6	<1.00	9.43	9.52	78.4	47.9	<1.00
LAW-HPVR-07-CCC-PCT-B	1	14	S-14395	<5.00	71.0	<5.00	69.0	18.0	565	181	<5.00
LAW-HPVR-03-1-CCC-PCT-C	1	15	S-14379	11.5	29.5	<5.00	33.8	18.4	161	55.5	<5.00
LAW-HPVR-15-CCC-PCT-A	1	16	S-14423	<5.00	164	<5.00	120	71.0	530	358	<5.00
LAW-HPVR-13-CCC-PCT-C	1	17	S-14419	<5.00	74.0	<5.00	55.5	31.9	412	289	<5.00
LRM-STD-PCT-B	1	18	S-14447	14.0	25.9	<5.00	<5.00	<5.00	163	76.0	<5.00
LAW-HPVR-06-CCC-PCT-A	1	19	S-14391	<5.00	102	<5.00	108	19.2	339	159	<5.00
std-1	1	20	std-14	3.81	18.2	<1.00	9.24	9.38	76.4	47.4	<1.00
LAW-HPVR-02-1-CCC-PCT-B	1	21	S-14375	<5.00	368	<5.00	164	6.80	1110	301	<5.00
LRM-STD-PCT-1-C	1	22	S-14471	13.8	23.8	<5.00	<5.00	<5.00	156	74.0	<5.00
LAW-HPVR-22-CCC-PCT-C	1	23	S-14459	8.40	38.3	<5.00	27.5	14.7	298	97.0	<5.00
LAW-HPVR-25-CCC-PCT-A	1	24	S-14463	106	251	21.4	156	28.3	3285	275	<5.00
LRM-STD-PCT-B	1	25	S-14427	14.1	25.8	<5.00	<5.00	<5.00	164	75.5	<5.00
std-1	1	26	std-15	3.83	18.2	<1.00	9.05	9.38	76.9	47.5	<1.00
LAW-HPVR-05-CCC-PCT-A	1	27	S-14383	<5.00	284	5.30	14.8	152	840	478	<5.00
LAW-HPVR-16-CCC-PCT-A	1	28	S-14431	5.95	86.5	<5.00	22.2	13.0	313	80.0	<5.00
LAW-HPVR-10-CCC-PCT-A	1	29	S-14403	<5.00	555	<5.00	164	20.6	2335	710	<5.00
LAW-HPVR-01-1-CCC-PCT-A	1	30	S-14371	<5.00	535	<5.00	116	156	1590	458	<5.00
MQ WATER BLK-PCT-1-B	1	31	S-14473	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
std-1	1	32	std-16	3.86	18.5	<1.00	9.21	9.51	77.2	47.9	<1.00
std-2	2	1	std-21	3.97	19.2	<1.00	9.93	10.0	80.9	48.4	<1.00
LAW-HPVR-09-CCC-PCT-A	2	2	S-14400	<5.00	870	8.30	128	249	2445	800	<5.00
LAW-HPVR-21-CCC-PCT-C	2	3	S-14456	16.1	133	<5.00	80.5	<5.00	445	74.5	<5.00
LAW-HPVR-02-1-CCC-PCT-C	2	4	S-14376	<5.00	390	<5.00	179	6.90	1185	315	<5.00
LAW-HPVR-25-CCC-PCT-B	2	5	S-14464	106	253	21.2	161	28.9	3405	275	<5.00
LAW-HPVR-20-CCC-PCT-B	2	6	S-14452	<5.00	1335	17.7	5.10	31.8	5500	1565	<5.00
std-2	2	7	std-22	3.96	19.6	<1.00	10.1	9.92	83.7	49.7	<1.00
LAW-HPVR-17-CCC-PCT-C	2	8	S-14436	9.70	58.5	<5.00	43.5	12.3	218	65.0	<5.00
MQ WATER BLK-PCT-1-A	2	9	S-14472	<5.00	<5.00	<5.00	<5.00	<5.00	5.25	<5.00	<5.00
LAW-HPVR-14-CCC-PCT-A	2	10	S-14420	9.25	132	<5.00	<5.00	<5.00	780	164	<5.00
LRM-STD-PCT-C	2	11	S-14448	14.9	28.7	<5.00	<5.00	<5.00	178	79.5	<5.00
LAW-HPVR-26-CCC-PCT-C	2	12	S-14468	10.9	114	<5.00	31.7	40.6	296	85.5	<5.00
std-2	2	13	std-23	3.94	19.3	<1.00	9.60	9.95	81.0	48.2	<1.00
LAW-HPVR-16-CCC-PCT-B	2	14	S-14432	6.10	93.0	<5.00	24.8	13.3	335	82.5	<5.00
LAW-HPVR-07-CCC-PCT-C	2	15	S-14396	<5.00	75.5	<5.00	73.0	17.0	570	189	<5.00
LAW-HPVR-11-CCC-PCT-B	2	16	S-14412	<5.00	391	<5.00	190	21.9	1560	305	<5.00

Table A-2. CCC PCT Leachate Measurements (mg/L) Measured by ICP-OES (continued)

PNNL Solution ID	Block	Seq.	Lab ID	Al	B	Cr	K	Li	Na	Si	Zr
LAW-HPVR-19-CCC-PCT-A	2	17	S-14440	<5.00	44.9	<5.00	<5.00	16.8	351	159	<5.00
LAW-HPVR-06-CCC-PCT-B	2	18	S-14392	<5.00	100	<5.00	107	18.0	344	162	<5.00
LAW-HPVR-05-CCC-PCT-B	2	19	S-14384	<5.00	315	5.50	15.9	169	960	520	<5.00
std-2	2	20	std-24	3.95	19.4	<1.00	9.74	9.93	82.2	48.8	<1.00
LAW-HPVR-24-CCC-PCT-A	2	21	S-14460	<5.00	192	<5.00	253	113	930	515	<5.00
LAW-HPVR-10-CCC-PCT-B	2	22	S-14404	<5.00	560	<5.00	169	20.5	2365	690	<5.00
LAW-HPVR-04-1-CCC-PCT-A	2	23	S-14380	<5.00	277	9.30	59.5	151	1105	635	<5.00
LAW-HPVR-15-CCC-PCT-B	2	24	S-14424	<5.00	169	<5.00	125	72.5	540	364	<5.00
LRM-STD-PCT-C	2	25	S-14388	13.9	25.9	<5.00	<5.00	<5.00	161	72.5	<5.00
std-2	2	26	std-25	3.90	19.0	<1.00	9.73	9.78	80.3	47.9	<1.00
LAW-HPVR-23-CCC-PCT-B	2	27	S-14444	<5.00	53.5	<5.00	14.0	9.75	471	166	<5.00
LAW-HPVR-01-1-CCC-PCT-B	2	28	S-14372	<5.00	550	<5.00	130	171	1655	497	<5.00
LRM-STD-PCT-C	2	29	S-14428	14.8	28.3	<5.00	<5.00	<5.00	172	79.0	<5.00
LAW-HPVR-12-CCC-PCT-C	2	30	S-14416	<5.00	36.6	<5.00	<5.00	17.5	483	231	<5.00
LRM-STD-PCT-C	2	31	S-14408	14.6	27.8	<5.00	<5.00	<5.00	171	77.5	<5.00
std-2	2	32	std-26	3.99	19.5	<1.00	9.87	9.82	82.3	48.8	<1.00
std-3	3	1	std-31	4.05	19.3	<1.00	10.3	10.1	83.0	49.5	<1.00
LAW-HPVR-15-CCC-PCT-C	3	2	S-14425	<5.00	170	<5.00	126	74.5	570	372	<5.00
LAW-HPVR-20-CCC-PCT-C	3	3	S-14453	<5.00	1390	17.6	5.75	31.9	6000	1610	<5.00
MQ WATER BLK-PCT-A	3	4	S-14389	<5.00	<5.00	<5.00	<5.00	<5.00	6.10	<5.00	<5.00
LAW-HPVR-09-CCC-PCT-B	3	5	S-14401	<5.00	905	8.55	126	249	2550	860	<5.00
LAW-HPVR-16-CCC-PCT-C	3	6	S-14433	6.00	90.5	<5.00	24.4	13.1	329	83.5	<5.00
std-3	3	7	std-32	4.02	19.3	<1.00	9.91	9.84	82.8	49.2	<1.00
LAW-HPVR-04-1-CCC-PCT-B	3	8	S-14381	<5.00	259	8.75	58.0	150	1250	710	<5.00
LAW-HPVR-23-CCC-PCT-C	3	9	S-14445	<5.00	56.0	<5.00	15.6	10.1	492	171	<5.00
MQ WATER BLK-PCT-A	3	10	S-14449	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
LAW-HPVR-25-CCC-PCT-C	3	11	S-14465	108	256	22.0	166	29.6	3400	288	<5.00
LAW-HPVR-01-1-CCC-PCT-C	3	12	S-14373	<5.00	580	<5.00	129	169	1725	490	<5.00
std-3	3	13	std-33	4.02	19.3	<1.00	10.1	10.0	83.0	49.1	<1.00
LAW-HPVR-10-CCC-PCT-C	3	14	S-14405	<5.00	500	<5.00	171	21.1	2120	610	<5.00
LAW-HPVR-05-CCC-PCT-C	3	15	S-14385	<5.00	308	5.80	16.8	166	1005	520	<5.00
LAW-HPVR-19-CCC-PCT-B	3	16	S-14441	<5.00	44.8	<5.00	<5.00	16.6	350	158	<5.00
LRM-STD-PCT-B	3	17	S-14407	14.6	27.4	<5.00	<5.00	<5.00	172	76.5	<5.00
MQ WATER BLK-PCT-A	3	18	S-14409	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
LAW-HPVR-03-1-CCC-PCT-A	3	19	S-14377	12.1	34.6	<5.00	38.1	17.8	179	58.0	<5.00
std-3	3	20	std-34	4.10	19.6	<1.00	10.2	9.97	84.3	49.6	<1.00
LAW-HPVR-18-CCC-PCT-A	3	21	S-14437	<5.00	269	<5.00	30.1	92.0	865	253	<5.00
MQ WATER BLK-PCT-A	3	22	S-14429	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
LAW-HPVR-22-CCC-PCT-A	3	23	S-14457	9.05	43.6	<5.00	30.0	15.5	340	104	<5.00
LAW-HPVR-14-CCC-PCT-B	3	24	S-14421	8.75	123	<5.00	<5.00	<5.00	820	154	<5.00
MQ WATER BLK-PCT-B	3	25	S-14410	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
std-3	3	26	std-35	4.09	19.5	<1.00	10.0	9.91	84.1	49.2	<1.00
LAW-HPVR-13-CCC-PCT-A	3	27	S-14417	<5.00	80.5	<5.00	61.5	34.7	452	308	<5.00
LAW-HPVR-24-CCC-PCT-B	3	28	S-14461	<5.00	191	<5.00	255	116	980	515	<5.00
LAW-HPVR-06-CCC-PCT-C	3	29	S-14393	<5.00	108	<5.00	118	17.2	367	161	<5.00
LAW-HPVR-08-CCC-PCT-A	3	30	S-14397	15.9	71.5	<5.00	26.6	27.3	213	55.5	<5.00
LAW-HPVR-11-CCC-PCT-C	3	31	S-14413	<5.00	405	<5.00	201	23.3	1580	322	<5.00
std-3	3	32	std-36	4.10	19.6	<1.00	10.3	10.0	83.6	49.5	<1.00

Table A-2. CCC PCT Leachate Measurements (mg/L) Measured by ICP-OES (continued)

PNNL Solution ID	Block	Seq.	Lab ID	Al	B	Cr	K	Li	Na	Si	Zr
std-4	4	1	std-41	3.98	19.5	<1.00	10.1	10.0	83.7	49.4	<1.00
LAW-HPVR-17-CCC-PCT-A	4	2	S-14434	9.80	59.0	<5.00	45.5	11.9	215	64.0	<5.00
LRM-STD-PCT-A	4	3	S-14406	15.1	28.6	<5.00	<5.00	<5.00	179	79.5	<5.00
MQ WATER BLK-PCT-B	4	4	S-14430	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
LAW-HPVR-02-1-CCC-PCT-A	4	5	S-14374	<5.00	396	<5.00	183	8.05	1170	321	<5.00
LRM-STD-PCT-A	4	6	S-14426	13.4	26.1	<5.00	<5.00	<5.00	164	71.0	<5.00
std-4	4	7	std-42	4.05	19.5	<1.00	10.4	10.3	85.9	49.8	<1.00
LAW-HPVR-21-CCC-PCT-A	4	8	S-14454	16.3	137	<5.00	86.0	<5.00	471	72.0	<5.00
MQ WATER BLK-PCT-B	4	9	S-14390	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
MQ WATER BLK-PCT-B	4	10	S-14450	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
LAW-HPVR-07-CCC-PCT-A	4	11	S-14394	<5.00	78.0	<5.00	79.0	17.4	595	198	<5.00
LRM-STD-PCT-A	4	12	S-14386	13.3	24.2	<5.00	<5.00	<5.00	166	78.5	<5.00
std-4	4	13	std-43	4.07	19.5	<1.00	10.6	10.3	87.1	50.0	<1.00
LAW-HPVR-04-1-CCC-PCT-C	4	14	S-14382	<5.00	274	9.30	60.5	157	1180	670	<5.00
LRM-STD-PCT-1-B	4	15	S-14470	15.1	27.2	<5.00	<5.00	<5.00	175	79.5	<5.00
LAW-HPVR-19-CCC-PCT-C	4	16	S-14442	<5.00	47.0	<5.00	<5.00	16.8	364	163	<5.00
LAW-HPVR-13-CCC-PCT-B	4	17	S-14418	<5.00	80.5	<5.00	62.0	34.0	454	305	<5.00
LAW-HPVR-18-CCC-PCT-B	4	18	S-14438	<5.00	296	<5.00	31.9	96.0	800	278	<5.00
LAW-HPVR-14-CCC-PCT-C	4	19	S-14422	8.80	124	<5.00	<5.00	<5.00	775	154	<5.00
std-4	4	20	std-44	4.09	19.7	<1.00	10.3	9.63	84.2	49.2	<1.00
LRM-STD-PCT-A	4	21	S-14446	15.3	28.7	<5.00	<5.00	<5.00	177	79.0	<5.00
LAW-HPVR-12-CCC-PCT-A	4	22	S-14414	<5.00	35.9	<5.00	<5.00	16.9	468	224	<5.00
LRM-STD-PCT-1-A	4	23	S-14469	14.0	27.1	<5.00	<5.00	<5.00	166	74.5	<5.00
LAW-HPVR-24-CCC-PCT-C	4	24	S-14462	<5.00	191	<5.00	250	110	950	510	<5.00
LAW-HPVR-26-CCC-PCT-A	4	25	S-14466	10.5	110	<5.00	30.3	38.3	285	81.0	<5.00
std-4	4	26	std-45	3.99	19.4	<1.00	9.82	9.41	80.7	47.9	<1.00
LAW-HPVR-22-CCC-PCT-B	4	27	S-14458	8.75	42.0	<5.00	28.6	14.5	315	98.0	<5.00
LAW-HPVR-09-CCC-PCT-C	4	28	S-14402	<5.00	880	7.90	123	233	2390	790	<5.00
LAW-HPVR-08-CCC-PCT-B	4	29	S-14398	15.4	72.5	<5.00	26.2	26.7	207	55.5	<5.00
LAW-HPVR-03-1-CCC-PCT-B	4	30	S-14378	11.7	32.6	<5.00	35.8	16.9	168	57.0	<5.00
std-4	4	31	std-46	3.94	19.3	<1.00	9.38	9.53	79.6	47.6	<1.00

Table A-3. Set 3 PCT Leachate Measurements (mg/L) Measured by ICP-OES

PNNL Solution ID	Block	Seq.	Lab ID	Al	B	Cr	K	Li	Na	Si	Zr
std	1	1	std-11	3.90	19.6	<1.00	9.73	10.1	82.1	49.1	<1.00
LAW-HPVR-02-1-Q-PCT-B-1	1	2	S-15346	<5.00	332	<5.00	156	5.65	1035	293	<5.00
LAW-HPVR-10-CCC-PCT-A-1	1	3	S-15337	<5.00	473	<5.00	133	17.7	1950	640	<5.00
LAW-HPVR-05-Q-PCT-C-1	1	4	S-15376	<5.00	440	6.75	23.0	222	1330	650	<5.00
LAW-HPVR-26-Q-PCT-C-1	1	5	S-15382	23.3	90.0	<5.00	23.9	31.6	269	65.5	<5.00
LAW-HPVR-11-Q-PCT-B-1	1	6	S-15349	<5.00	505	<5.00	228	28.6	1950	361	<5.00
LAW-HPVR-13-Q-PCT-B-1	1	7	S-15355	<5.00	100	<5.00	68.5	41.0	535	351	<5.00
MQ-WATER-BLK-PCT-B-2	1	8	S-15364	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
std	1	9	std-12	3.86	19.5	<1.00	9.45	10.0	80.5	48.8	<1.00
STD-ARM-PCT-C-3	1	10	S-15385	<5.00	21.6	<5.00	<5.00	16.1	40.7	67.5	<5.00
LAW-HPVR-15-Q-PCT-B-1	1	11	S-15358	<5.00	223	<5.00	143	90.0	700	446	<5.00
LAW-HPVR-07-CCC-PCT-A-1	1	12	S-15328	<5.00	73.5	<5.00	64.5	16.0	555	185	<5.00
LAW-HPVR-08-CCC-PCT-A-1	1	13	S-15331	15.3	71.5	<5.00	23.5	27.5	196	55.0	<5.00
LAW-HPVR-04-1-Q-PCT-C-1	1	14	S-15373	<5.00	369	12.0	70.0	188	1425	830	<5.00
LAW-HPVR-03-1-Q-PCT-C-1	1	15	S-15370	11.6	34.8	<5.00	36.5	18.2	174	59.5	<5.00
LAW-HPVR-01-1-Q-PCT-C-1	1	16	S-15367	<5.00	590	<5.00	126	168	1695	497	<5.00
std	1	17	std-13	3.86	19.6	<1.00	9.49	9.96	79.8	48.6	<1.00
LAW-HPVR-06-CCC-PCT-A-1	1	18	S-15325	<5.00	114	<5.00	112	18.3	357	166	<5.00
LAW-HPVR-09-CCC-PCT-A-1	1	19	S-15334	<5.00	930	8.20	116	253	2480	925	<5.00
STD-ARM-PCT-B-2	1	20	S-15361	5.25	19.3	<5.00	<5.00	14.8	38.1	66.0	<5.00
MQ-WATER-BLK-PCT-A-1	1	21	S-15343	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
LAW-HPVR-14-Q-PCT-C-1	1	22	S-15379	7.60	146	<5.00	<5.00	<5.00	870	170	<5.00
LAW-HPVR-12-Q-PCT-B-1	1	23	S-15352	<5.00	41.8	<5.00	<5.00	15.4	530	254	<5.00
STD-ARM-PCT-A-1	1	24	S-15340	<5.00	20.9	<5.00	<5.00	15.6	43.6	67.0	<5.00
std	1	25	std-14	3.90	19.7	<1.00	9.48	10.1	81.3	48.8	<1.00
std	2	1	std-21	3.90	19.7	<1.00	9.49	10.1	80.3	49.5	<1.00
MQ-WATER-BLK-PCT-A-3	2	2	S-15386	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
LAW-HPVR-01-1-Q-PCT-A-1	2	3	S-15365	<5.00	575	<5.00	123	163	1605	487	<5.00
LAW-HPVR-15-Q-PCT-C-1	2	4	S-15359	<5.00	205	<5.00	134	84.5	650	420	<5.00
LAW-HPVR-02-1-Q-PCT-C-1	2	5	S-15347	<5.00	321	<5.00	144	5.50	930	285	<5.00
LAW-HPVR-06-CCC-PCT-B-1	2	6	S-15326	<5.00	111	<5.00	109	17.5	349	166	<5.00
LAW-HPVR-09-CCC-PCT-B-1	2	7	S-15335	<5.00	900	8.30	113	245	2350	905	<5.00
LAW-HPVR-14-Q-PCT-A-1	2	8	S-15377	7.65	138	<5.00	<5.00	<5.00	785	168	<5.00
std	2	9	std-22	3.88	19.9	<1.00	9.55	10.1	80.2	49.9	<1.00
LAW-HPVR-13-Q-PCT-C-1	2	10	S-15356	<5.00	99.0	<5.00	65.5	40.5	520	357	<5.00
LAW-HPVR-11-Q-PCT-C-1	2	11	S-15350	<5.00	444	<5.00	205	25.0	1685	325	<5.00
LAW-HPVR-08-CCC-PCT-B-1	2	12	S-15332	14.2	66.5	<5.00	22.2	25.9	187	50.5	<5.00
LAW-HPVR-07-CCC-PCT-B-1	2	13	S-15329	<5.00	61.5	<5.00	54.5	13.4	476	162	<5.00
STD-ARM-PCT-A-3	2	14	S-15383	<5.00	18.2	<5.00	<5.00	13.8	40.9	61.0	<5.00
LAW-HPVR-12-Q-PCT-C-1	2	15	S-15353	<5.00	40.4	<5.00	<5.00	15.3	520	255	<5.00
MQ-WATER-BLK-PCT-B-1	2	16	S-15344	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
std	2	17	std-23	3.98	19.7	<1.00	9.51	10.0	80.3	50.1	<1.00
STD-ARM-PCT-B-1	2	18	S-15341	<5.00	22.0	<5.00	<5.00	15.9	48.9	68.5	<5.00
LAW-HPVR-26-Q-PCT-A-1	2	19	S-15380	23.7	90.0	<5.00	23.0	31.2	267	65.0	<5.00
LAW-HPVR-05-Q-PCT-A-1	2	20	S-15374	<5.00	457	6.80	22.5	223	1300	675	<5.00
LAW-HPVR-03-1-Q-PCT-A-1	2	21	S-15368	11.9	33.6	<5.00	35.6	17.7	173	58.5	<5.00
STD-ARM-PCT-C-2	2	22	S-15362	5.10	19.1	<5.00	<5.00	14.4	41.5	64.5	<5.00
LAW-HPVR-04-1-Q-PCT-A-1	2	23	S-15371	<5.00	370	12.1	70.0	194	1410	855	<5.00

Table A-3. Set 3 PCT Leachate Measurements (mg/L) Measured by ICP-OES (continued)

PNNL Solution ID	Block	Seq.	Lab ID	Al	B	Cr	K	Li	Na	Si	Zr
LAW-HPVR-10-CCC-PCT-B-1	2	24	S-15338	<5.00	520	<5.00	140	18.9	2025	685	<5.00
std	2	25	std-24	3.96	19.3	<1.00	9.41	9.95	79.9	49.2	<1.00
std	3	1	std-31	4.16	20.7	<1.00	9.39	9.92	79.3	51.0	<1.00
LAW-HPVR-08-CCC-PCT-C-1	3	2	S-15333	15.0	70.5	<5.00	24.2	27.3	196	53.5	<5.00
LAW-HPVR-11-Q-PCT-A-1	3	3	S-15348	<5.00	530	<5.00	239	29.4	1955	377	<5.00
LAW-HPVR-04-1-Q-PCT-B-1	3	4	S-15372	<5.00	367	11.9	71.0	189	1390	830	<5.00
MQ-WATER-BLK-PCT-B-3	3	5	S-15387	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
STD-ARM-PCT-C-1	3	6	S-15342	<5.00	22.8	<5.00	<5.00	15.9	49.8	69.0	<5.00
LAW-HPVR-03-1-Q-PCT-B-1	3	7	S-15369	11.8	35.2	<5.00	37.6	18.1	176	59.0	<5.00
LAW-HPVR-15-Q-PCT-A-1	3	8	S-15357	<5.00	214	<5.00	140	88.0	670	433	<5.00
std	3	9	std-32	3.93	20.0	<1.00	9.67	10.1	80.3	49.4	<1.00
LAW-HPVR-01-1-Q-PCT-B-1	3	10	S-15366	<5.00	610	<5.00	130	172	1675	505	<5.00
LAW-HPVR-07-CCC-PCT-C-1	3	11	S-15330	<5.00	73.5	<5.00	64.0	15.6	545	189	<5.00
LAW-HPVR-14-Q-PCT-B-1	3	12	S-15378	7.90	149	<5.00	<5.00	<5.00	810	173	<5.00
STD-ARM-PCT-B-3	3	13	S-15384	5.05	18.8	<5.00	<5.00	13.9	40.9	63.5	<5.00
LAW-HPVR-09-CCC-PCT-C-1	3	14	S-15336	<5.00	940	8.30	120	260	2465	935	<5.00
STD-ARM-PCT-A-2	3	15	S-15360	5.25	20.2	<5.00	<5.00	14.8	43.2	67.0	<5.00
LAW-HPVR-02-1-Q-PCT-A-1	3	16	S-15345	<5.00	349	<5.00	148	5.60	970	297	<5.00
std	3	17	std-33	3.95	19.5	<1.00	9.09	9.57	77.0	48.5	<1.00
LAW-HPVR-12-Q-PCT-A-1	3	18	S-15351	<5.00	39.3	<5.00	<5.00	14.6	500	240	<5.00
LAW-HPVR-10-CCC-PCT-C-1	3	19	S-15339	<5.00	486	<5.00	132	17.6	1900	630	<5.00
LAW-HPVR-13-Q-PCT-A-1	3	20	S-15354	<5.00	98.0	<5.00	68.0	40.8	525	343	<5.00
LAW-HPVR-26-Q-PCT-B-1	3	21	S-15381	23.1	90.5	<5.00	23.8	31.3	265	63.5	<5.00
LAW-HPVR-06-CCC-PCT-C-1	3	22	S-15327	<5.00	107	<5.00	100	15.9	322	158	<5.00
LAW-HPVR-05-Q-PCT-B-1	3	23	S-15375	<5.00	457	6.70	24.1	231	1335	665	<5.00
MQ-WATER-BLK-PCT-A-2	3	24	S-15363	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
std	3	25	std-34	3.85	19.5	<1.00	9.96	10.3	82.1	48.3	<1.00

Table A-4. Dilution-Corrected LRM Leachate Measurements (mg/L)

PNNL Solution ID	PNNL Grouping	Lab ID	B	Na	Si
LRM-STD-PCT-A	Q	S-14011	28.7	168	77.5
LRM-STD-PCT-B	Q	S-14012	30.6	180	85.5
LRM-STD-PCT-C	Q	S-14013	26.8	179	79
LRM-STD-PCT-A	Q	S-14031	23.9	173	85
LRM-STD-PCT-B	Q	S-14032	25.5	168	78.5
LRM-STD-PCT-C	Q	S-14033	23	166	78
LRM-STD-PCT-A	Q	S-14051	18.7	155	70.5
LRM-STD-PCT-B	Q	S-14052	21.2	160	79.5
LRM-STD-PCT-C	Q	S-14053	23.4	161	77.5
LRM-STD-PCT-A	Q	S-14071	31.7	184	87
LRM-STD-PCT-B	Q	S-14072	28.4	174	84
LRM-STD-PCT-C	Q	S-14073	30.1	186	85
LRM-STD-PCT-A	Q	S-14091	26.7	169	74.5
LRM-STD-PCT-B	Q	S-14092	27.6	164	79
LRM-STD-PCT-C	Q	S-14093	27.1	166	81.5
LRM-STD-PCT-A	Q	S-14099	28	180	82.5
LRM-STD-PCT-B	Q	S-14100	31.7	184	80.5
LRM-STD-PCT-C	Q	S-14101	32	189	83
LRM-STD-PCT-A	CCC	S-14386	24.2	166	78.5
LRM-STD-PCT-B	CCC	S-14387	28.5	177	79.5
LRM-STD-PCT-C	CCC	S-14388	25.9	161	72.5
LRM-STD-PCT-A	CCC	S-14406	28.6	179	79.5
LRM-STD-PCT-B	CCC	S-14407	27.4	172	76.5
LRM-STD-PCT-C	CCC	S-14408	27.8	171	77.5
LRM-STD-PCT-A	CCC	S-14426	26.1	164	71
LRM-STD-PCT-B	CCC	S-14427	25.8	164	75.5
LRM-STD-PCT-C	CCC	S-14428	28.3	172	79
LRM-STD-PCT-A	CCC	S-14446	28.7	177	79
LRM-STD-PCT-B	CCC	S-14447	25.9	163	76
LRM-STD-PCT-C	CCC	S-14448	28.7	178	79.5
LRM-STD-PCT-1-A	CCC	S-14469	27.1	166	74.5
LRM-STD-PCT-1-B	CCC	S-14470	27.2	175	79.5
LRM-STD-PCT-1-C	CCC	S-14471	23.8	156	74

Ranges of Expected Test Results for LRM[f]
Boron: 19.5 – 33.9 mg/L (26.7 ± 7.20 mg/L)
Sodium: 147 – 173 mg/L (160 ± 13.0 mg/L)
Silicon: 69.3 – 94.7 mg/L (82.0 ± 12.7 mg/L)
Values that fall outside of the reference ranges are shaded gray.

[f] W.L. Ebert and S.F. Wolf, "Round-Robin Testing of a Reference Glass for Low-Activity Waste Forms," Argonne National Laboratory, Argonne, IL, ANL-99/22, Revision 0, 1999

Table A-5. Dilution-Corrected ARM-1 Leachate Measurements (mg/L)

PNNL Solution ID	PNNL Grouping	Lab ID	B	Na	Si
STD-ARM-PCT-A-1	Set 3	S-15340	20.9	43.6	67.0
STD-ARM-PCT-B-1	Set 3	S-15341	22.0	48.9	68.5
STD-ARM-PCT-C-1	Set 3	S-15342	22.8	49.8	69.0
STD-ARM-PCT-A-2	Set 3	S-15360	20.2	43.2	67.0
STD-ARM-PCT-B-2	Set 3	S-15361	19.3	38.1	66.0
STD-ARM-PCT-C-2	Set 3	S-15362	19.1	41.5	64.5
STD-ARM-PCT-A-3	Set 3	S-15383	18.2	40.9	61.0
STD-ARM-PCT-B-3	Set 3	S-15384	18.8	40.9	63.5
STD-ARM-PCT-C-3	Set 3	S-15385	21.6	40.7	67.5

3σ Ranges for ARM-1 Test Results[g]
Boron: 2.18 – 29.3 mg/L (15.7 ± 13.6 mg/L)
Sodium: 20.7 – 43.7 mg/L (32.2 ± 11.5 mg/L)
Silicon: 46.9 – 68.9 mg/L (57.9 ± 11.0 mg/L)
Values that fall outside of the reference ranges are shaded grey.

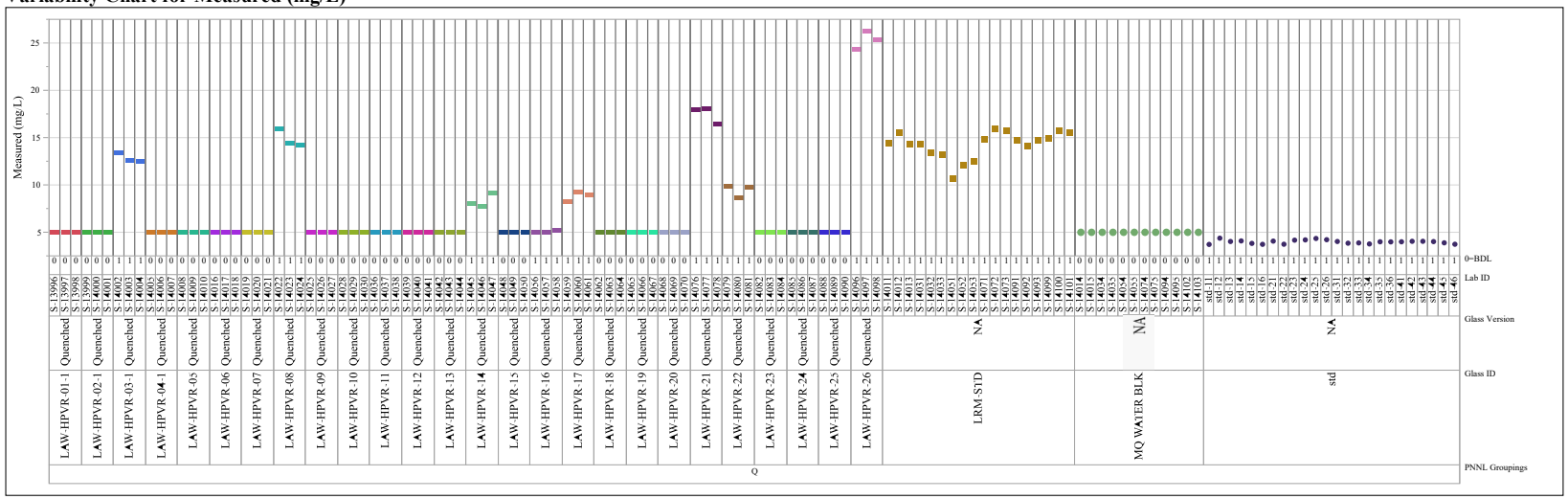
[g] W.L. Ebert, "The Precision of Product Consistency Tests with Reference Glasses ARM-1 and SRM 623," Argonne National Laboratory, Argonne, IL, ANL/CFCT-19/29, Rev. 0, 2019

Table A-6. Results from Samples of the Multi-Element Solution Standard Included with the PCT Leachates

Analytical Block	Q-1	Q-2	Q-3	Q-4	CCC-1	CCC-2	CCC-3	CCC-4	Set 3-1	Set 3-2	Set 3-3	Reference Values (mg/L)
Mean (Al (mg/L))	3.96	4.13	3.92	3.96	3.89	3.95	4.06	4.02	3.88	3.93	3.97	4.00
Mean (B (mg/L))	19.0	19.5	19.6	19.9	18.6	19.3	19.4	19.5	19.6	19.7	19.9	20.0
Mean (K (mg/L))	9.67	10.2	9.80	9.78	9.43	9.83	10.1	10.1	9.54	9.49	9.53	10.0
Mean (Li (mg/L))	10.0	9.92	9.85	9.96	9.53	9.90	9.97	9.86	10.0	10.0	9.97	10.0
Mean (Na (mg/L))	82.5	81.6	82.2	82.6	78.3	81.7	83.5	83.5	80.9	80.2	79.7	81.0
Mean (Si (mg/L))	49.0	49.1	47.8	50.2	48.0	48.6	49.4	49.0	48.8	49.7	49.3	50.0
% relative bias, Al	-0.9	3.1	-2.0	-1.0	-2.7	-1.2	1.6	0.5	-3.0	-1.8	-0.7	<10% per ASTM C1285
% relative bias, B	-4.9	-2.6	-1.9	-0.5	-6.9	-3.3	-2.8	-2.6	-2.0	-1.8	-0.4	
% relative bias, K	-3.3	1.8	-2.1	-2.2	-5.7	-1.7	1.3	1.0	-4.6	-5.1	-4.7	
% relative bias, Li	0.3	-0.8	-1.5	-0.4	-4.7	-1.0	-0.3	-1.4	0.4	0.4	-0.3	
% relative bias, Na	1.8	0.7	1.4	2.0	-3.4	0.9	3.0	3.1	-0.1	-1.0	-1.6	
% relative bias, Si	-2.1	-1.9	-4.4	0.3	-4.0	-2.7	-1.3	-2.0	-2.3	-0.7	-1.4	
Standard Deviation (Al (mg/L))	0.26	0.21	0.10	0.12	0.08	0.03	0.04	0.06	0.02	0.05	0.13	
Standard Deviation (B (mg/L))	0.70	0.44	0.72	0.50	0.41	0.22	0.15	0.13	0.08	0.25	0.57	
Standard Deviation (K (mg/L))	0.29	0.43	0.44	0.27	0.35	0.18	0.16	0.44	0.13	0.06	0.37	
Standard Deviation (Li (mg/L))	0.28	0.23	0.18	0.51	0.15	0.08	0.09	0.39	0.07	0.08	0.31	
Standard Deviation (Na (mg/L))	2.08	2.58	1.22	2.07	1.75	1.24	0.63	2.91	0.99	0.19	2.13	
Standard Deviation (Si (mg/L))	1.68	1.31	1.69	0.95	0.54	0.63	0.21	1.0	0.21	0.40	1.23	
%RSD (Al)	6.4	5.1	2.6	3.1	2.0	0.8	0.9	1.5	0.6	1.2	3.3	<10% per ASTM C1285
%RSD (B)	3.7	2.2	3.7	2.5	2.2	1.1	0.8	0.7	0.4	1.3	2.9	
%RSD (K)	3.0	4.2	4.5	2.8	3.7	1.8	1.6	4.4	1.4	0.6	3.9	
%RSD (Li)	2.8	2.3	1.8	5.1	1.5	0.8	0.9	4.0	0.7	0.7	3.1	
%RSD (Na)	2.5	3.2	1.5	2.5	2.2	1.5	0.8	3.5	1.2	0.2	2.7	
%RSD (Si)	3.4	2.7	3.5	1.9	1.1	1.3	0.4	2.0	0.4	0.8	2.5	

Exhibit A-1. PCT Measurements by Glass ID by PNNL Groupings

Analyte=Al
Variability Chart for Measured (mg/L)



Analyte=B
Variability Chart for Measured (mg/L)

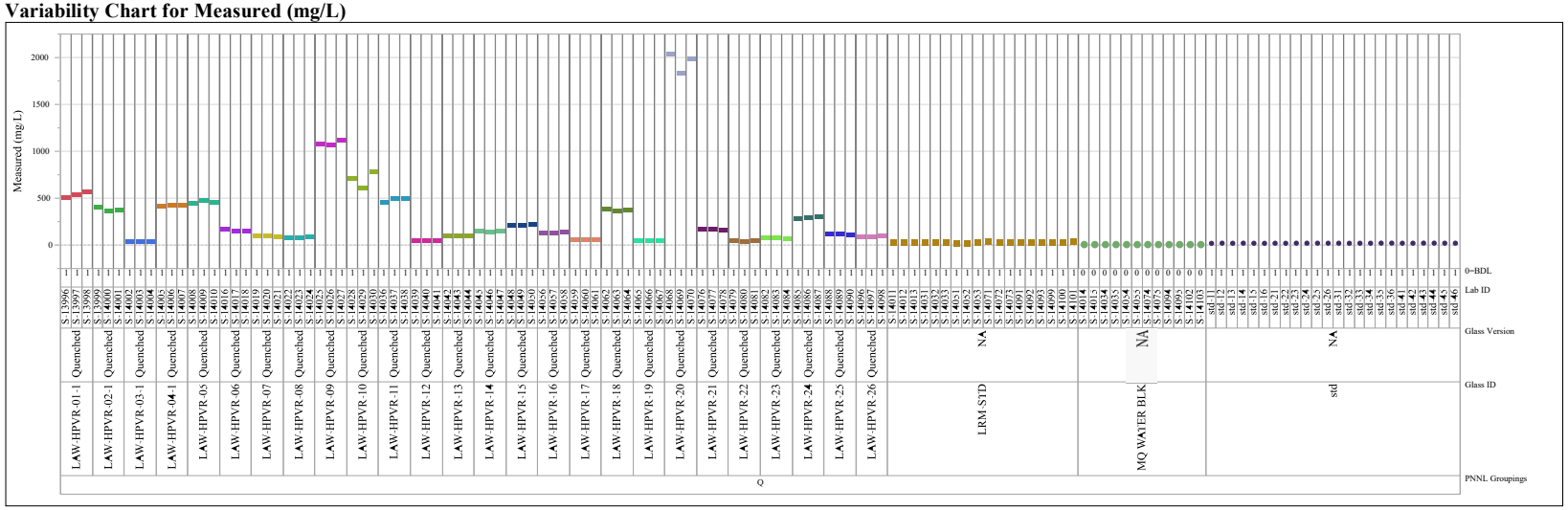
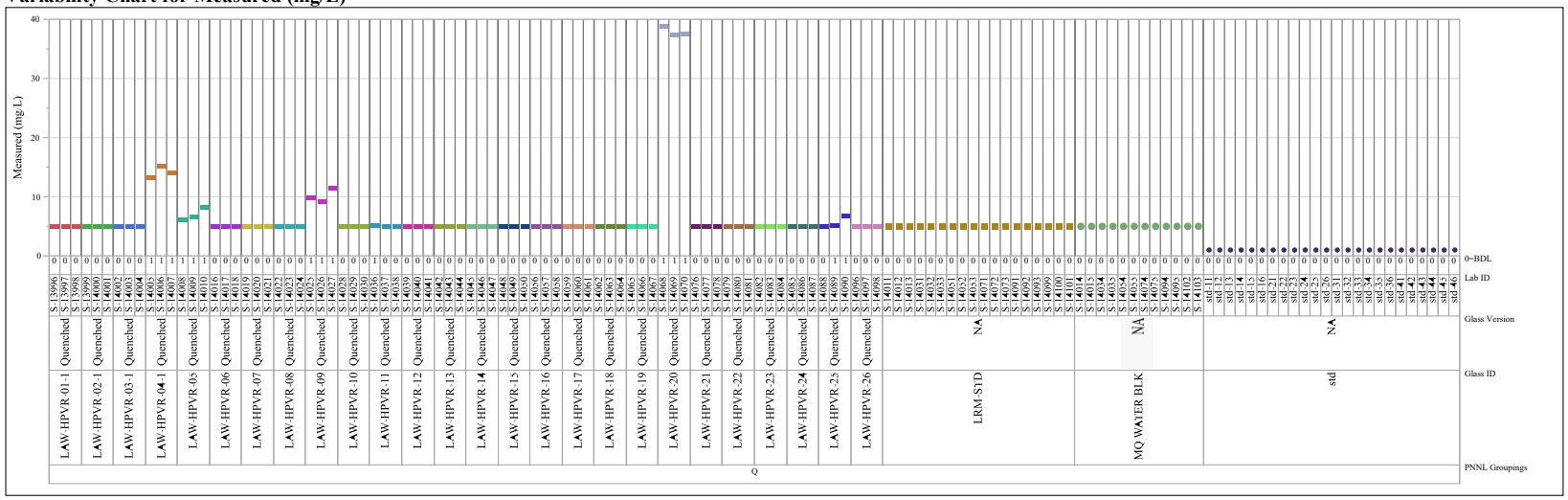


Exhibit A-1. PCT Measurements by Glass ID by PNNL Groupings (continued)

Analyte=Cr
Variability Chart for Measured (mg/L)



Analyte=K
Variability Chart for Measured (mg/L)

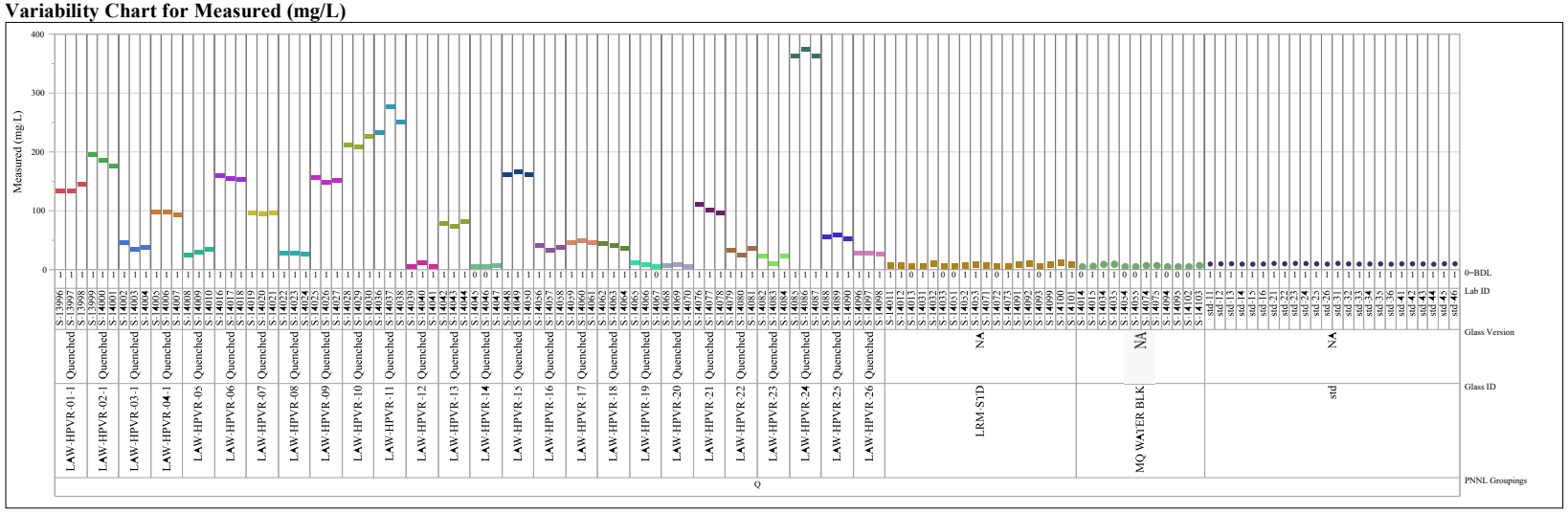
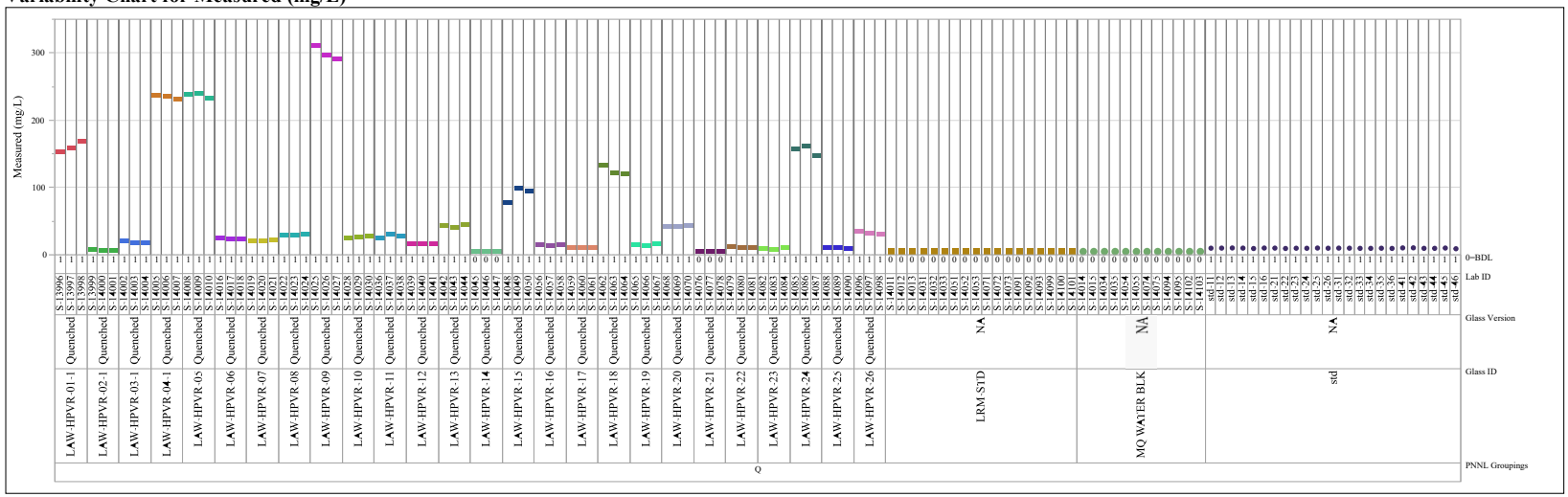


Exhibit A-1. PCT Measurements by Glass ID by PNNL Groupings (continued)

Analyte=Li
Variability Chart for Measured (mg/L)



Analyte=Na
Variability Chart for Measured (mg/L)

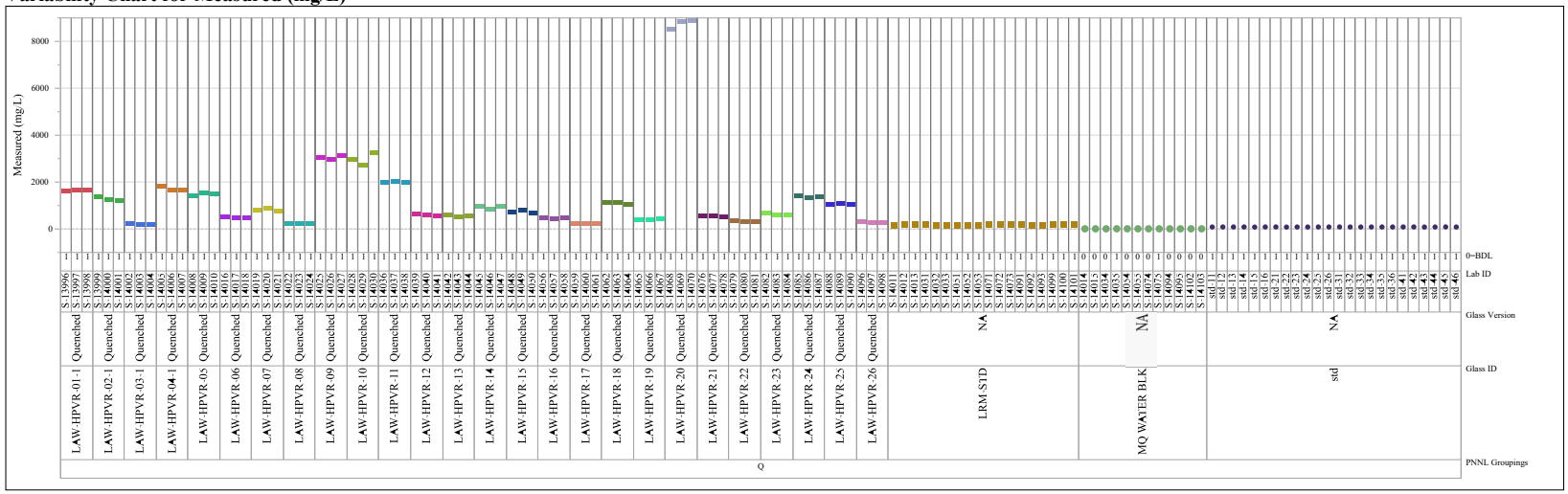
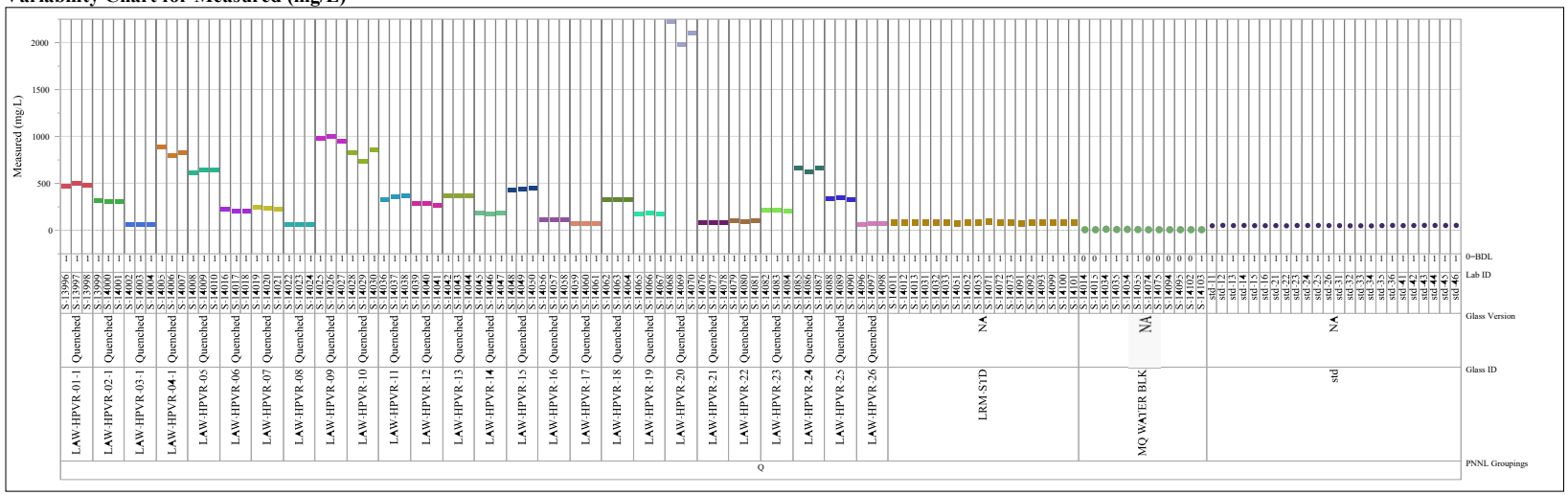


Exhibit A-1. PCT Measurements by Glass ID by PNNL Groupings (continued)

Analyte=Si
Variability Chart for Measured (mg/L)



Analyte=Zr
Variability Chart for Measured (mg/L)

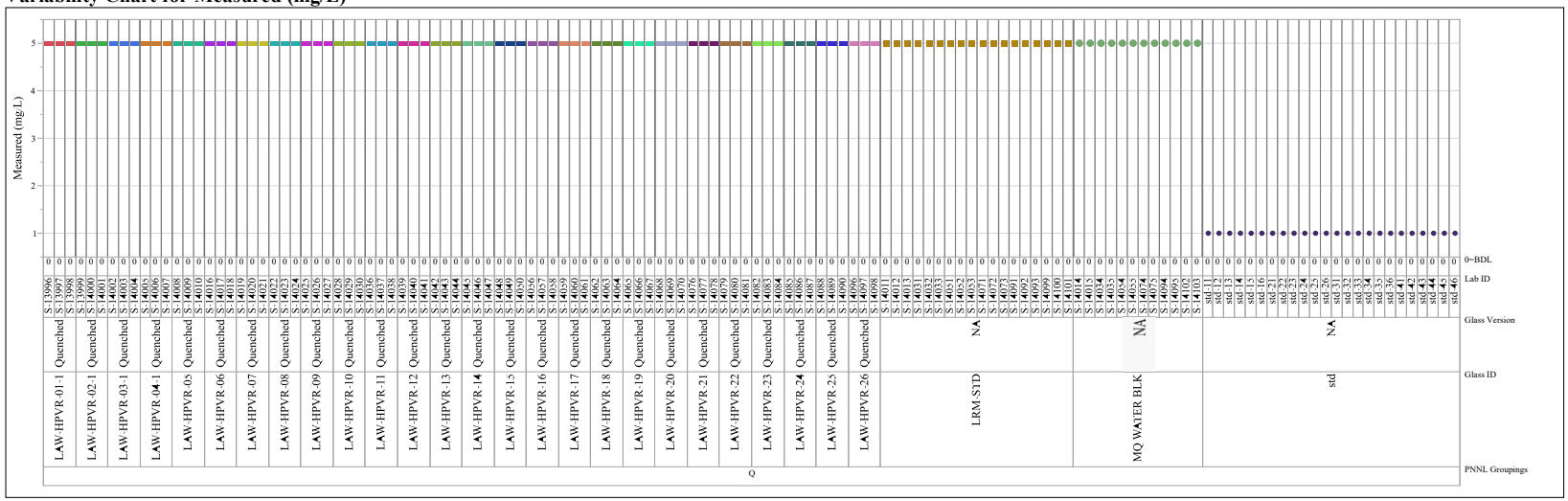
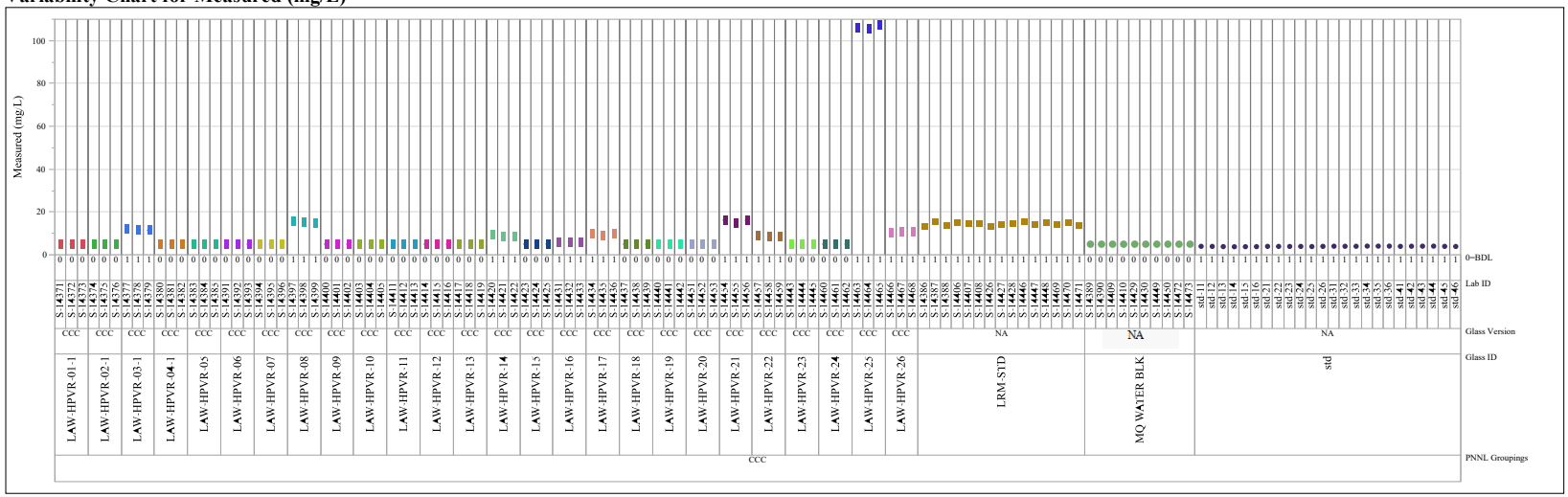


Exhibit A-1. PCT Measurements by Glass ID by PNNL Groupings (continued)

Analyte=Al
Variability Chart for Measured (mg/L)



Analyte=B
Variability Chart for Measured (mg/L)

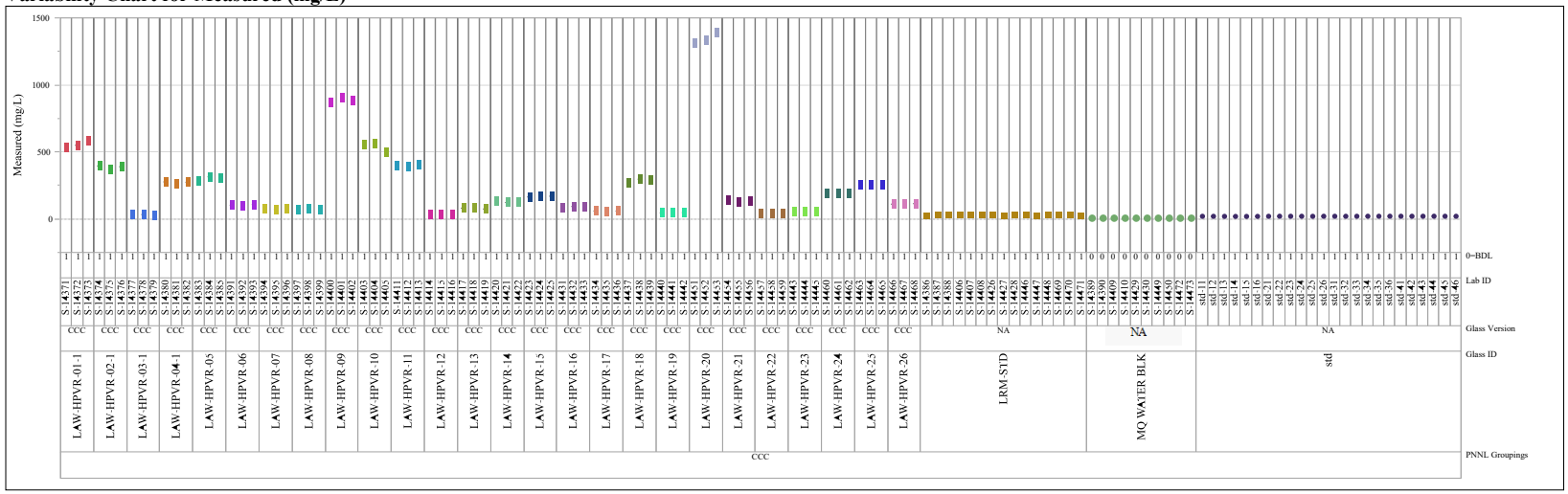
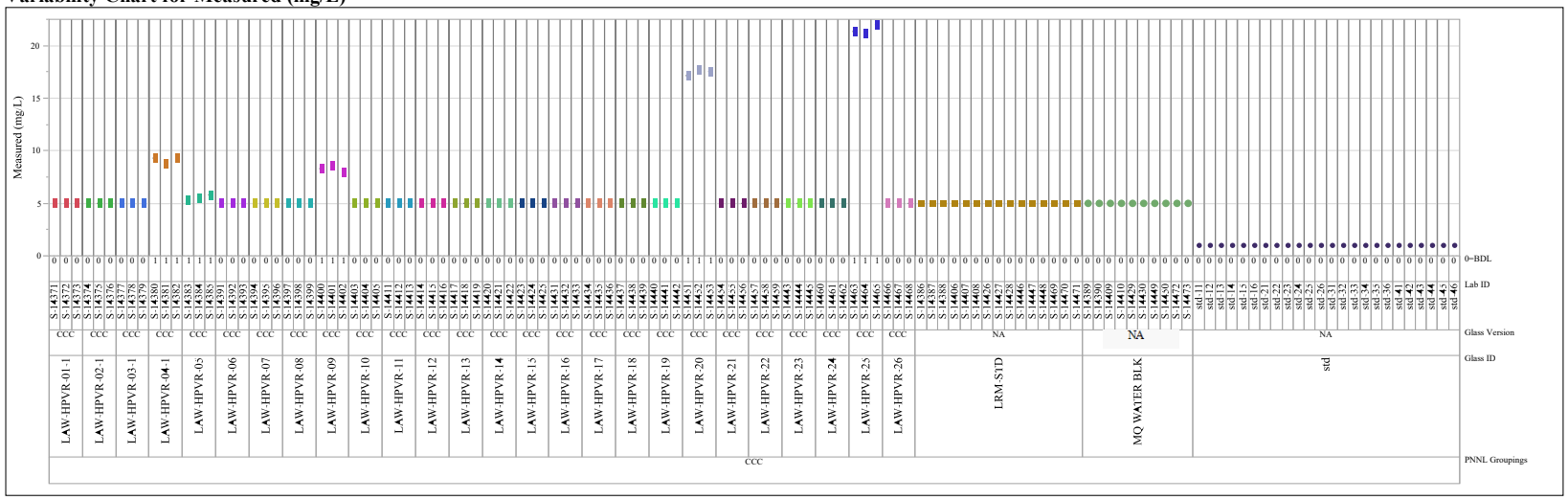


Exhibit A-1. PCT Measurements by Glass ID by PNNL Groupings (continued)

Analyte=Cr
Variability Chart for Measured (mg/L)



Analyte=K
Variability Chart for Measured (mg/L)

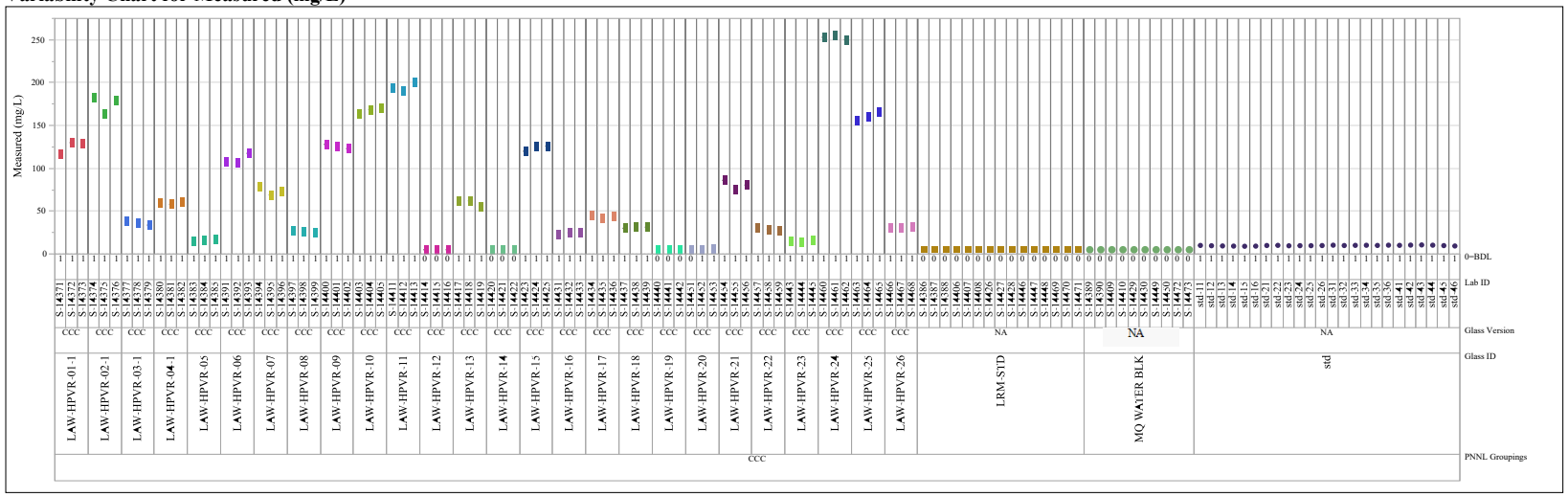
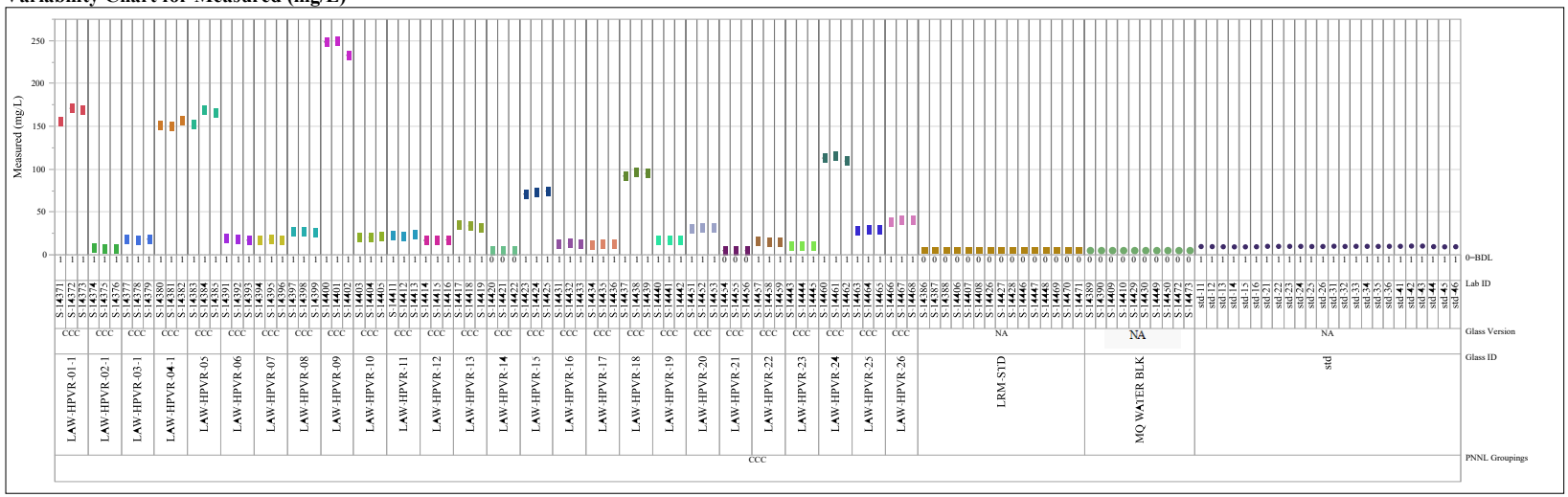


Exhibit A-1. PCT Measurements by Glass ID by PNNL Groupings (continued)

Analyte=Li
Variability Chart for Measured (mg/L)



Analyte=Na
Variability Chart for Measured (mg/L)

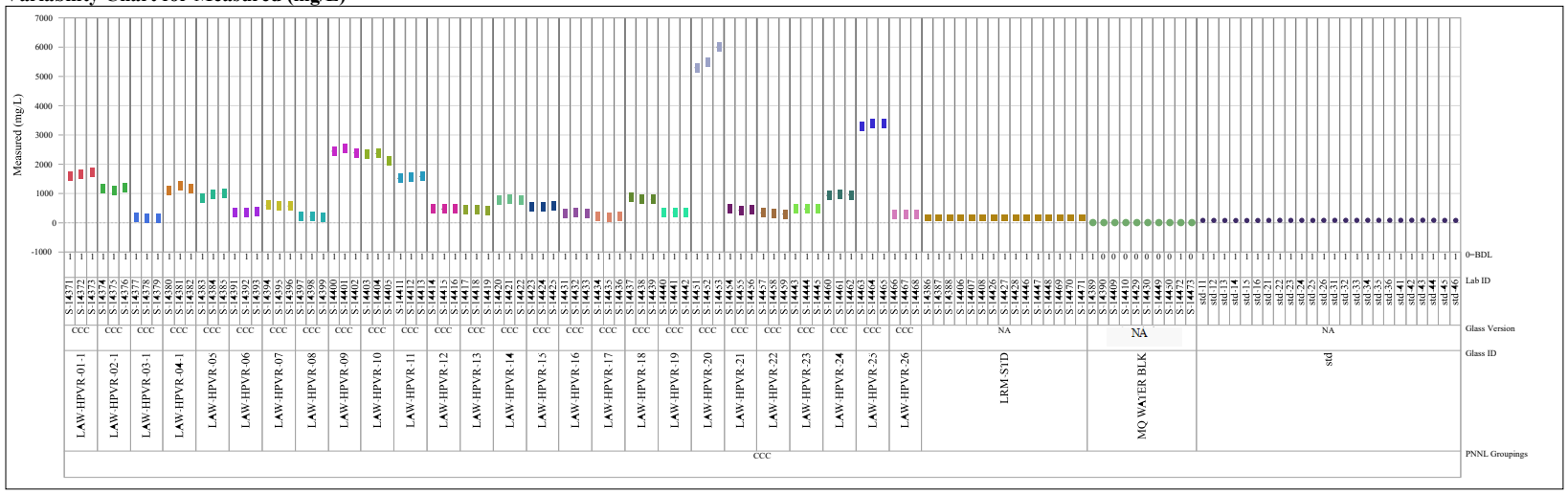
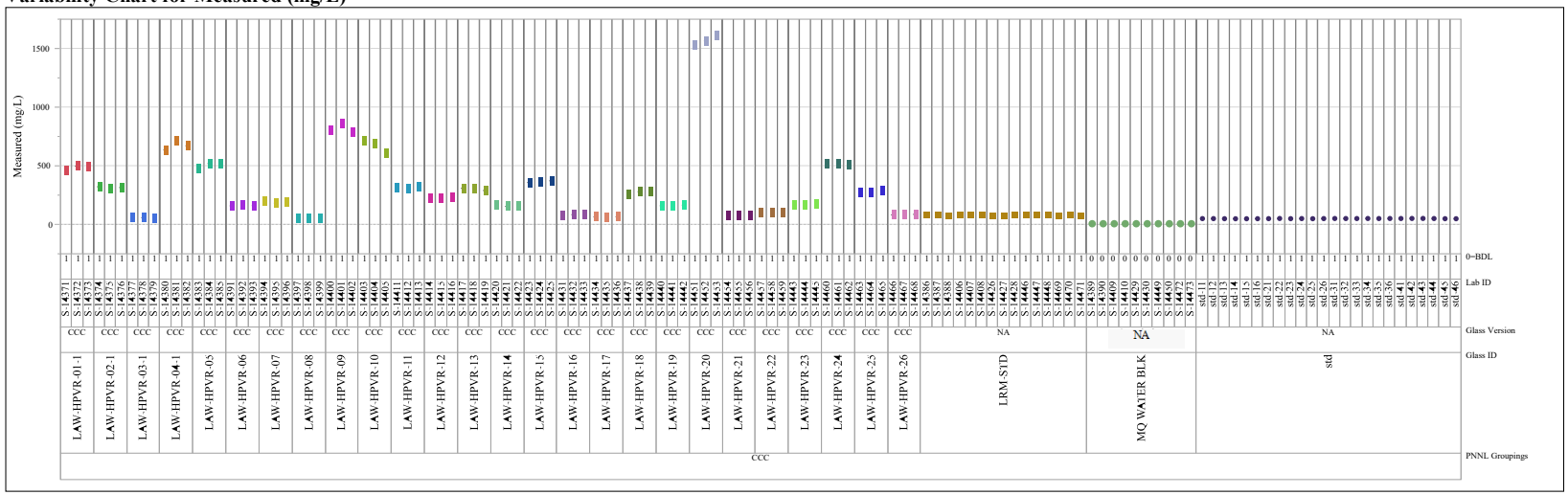


Exhibit A-1. PCT Measurements by Glass ID by PNNL Groupings (continued)

Analyte=Si
Variability Chart for Measured (mg/L)



Analyte=Zr
Variability Chart for Measured (mg/L)

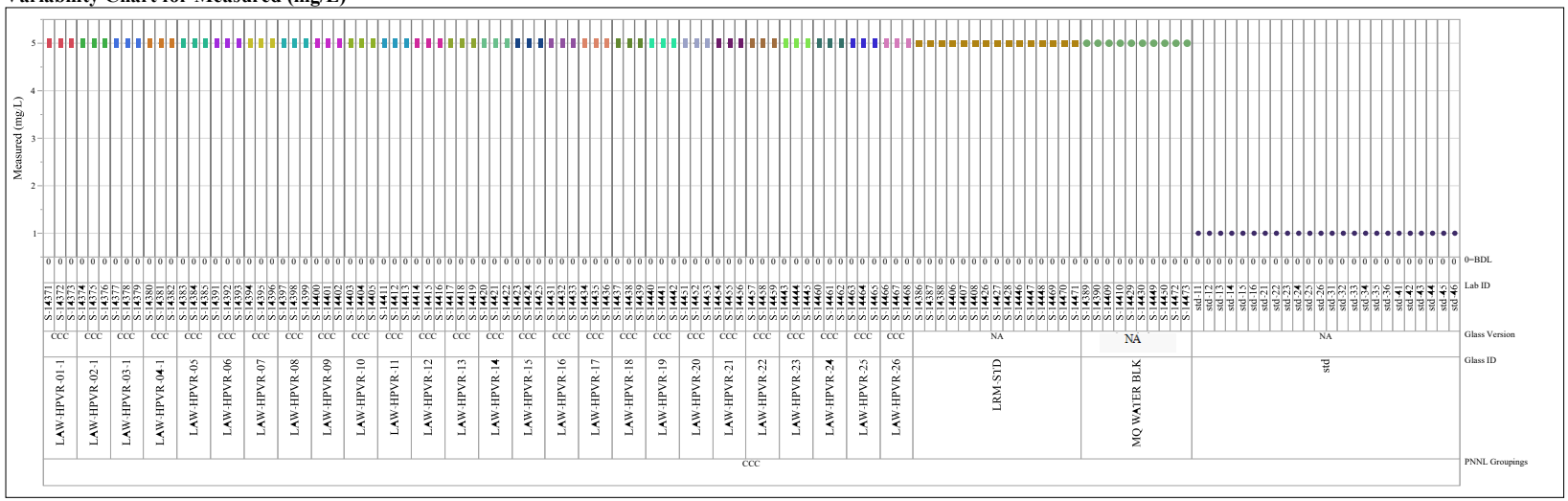
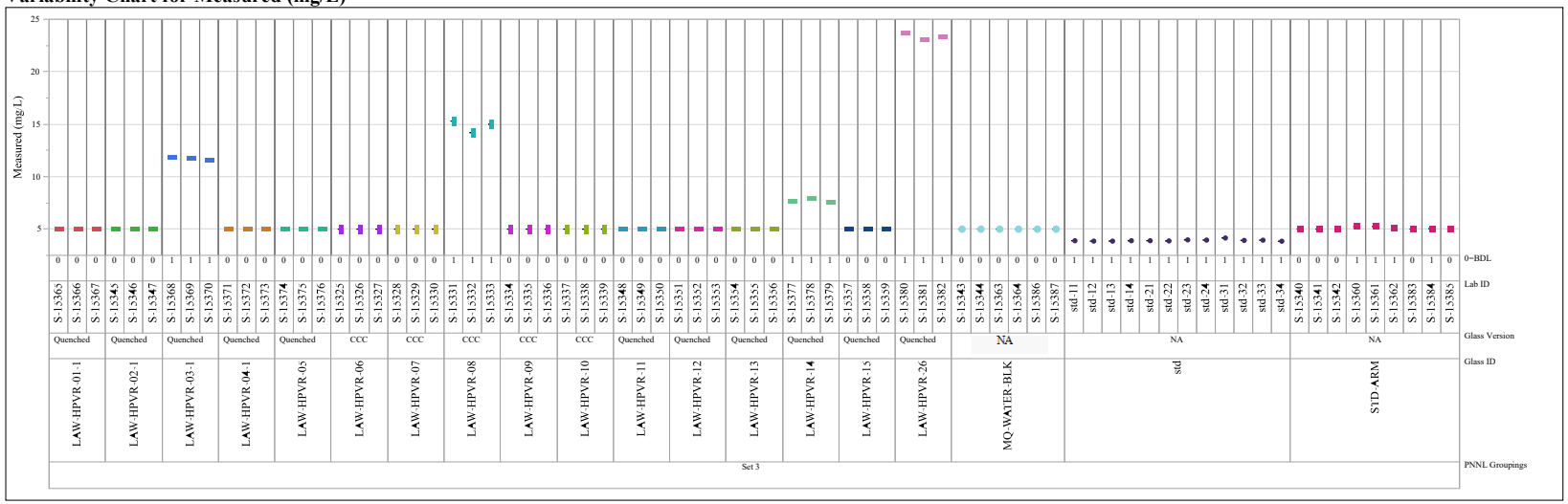


Exhibit A-1. PCT Measurements by Glass ID by PNNL Groupings (continued)

Analyte=Al
Variability Chart for Measured (mg/L)



Analyte=B
Variability Chart for Measured (mg/L)

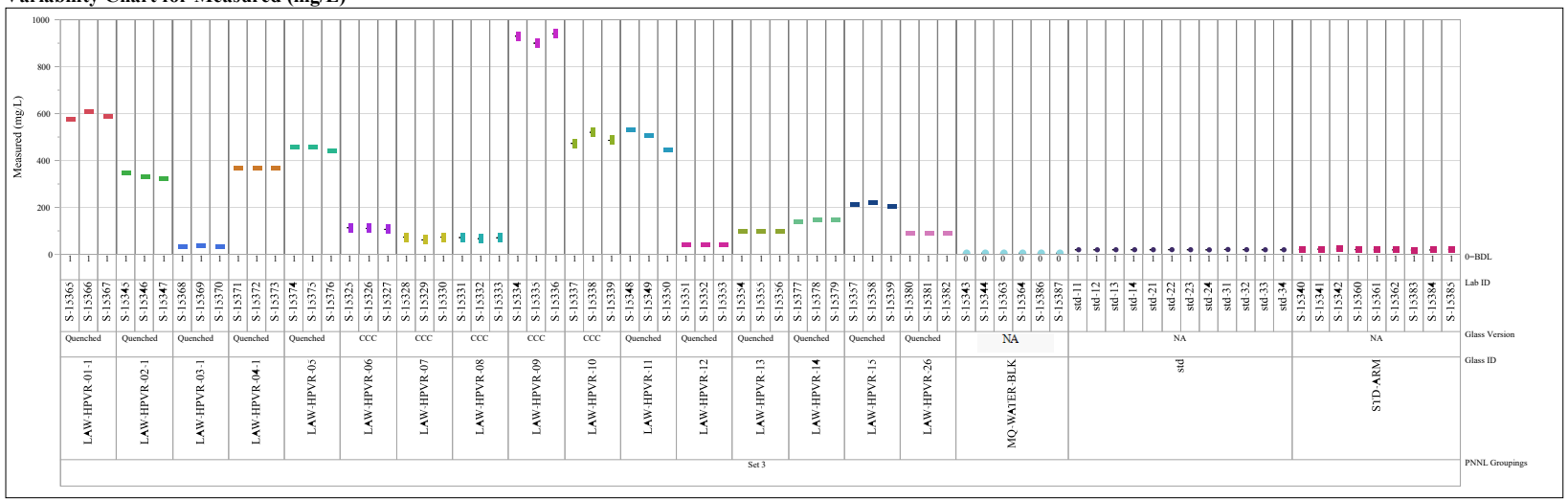
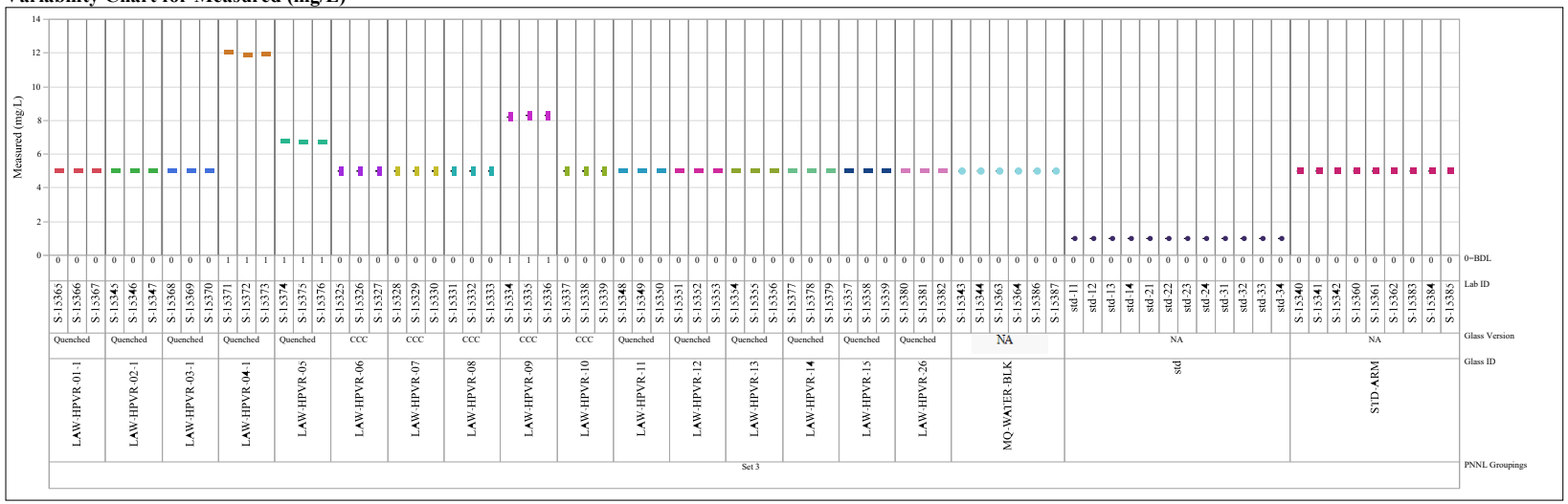


Exhibit A-1. PCT Measurements by Glass ID by PNNL Groupings (continued)

Analyte=Cr
Variability Chart for Measured (mg/L)



Analyte=K
Variability Chart for Measured (mg/L)

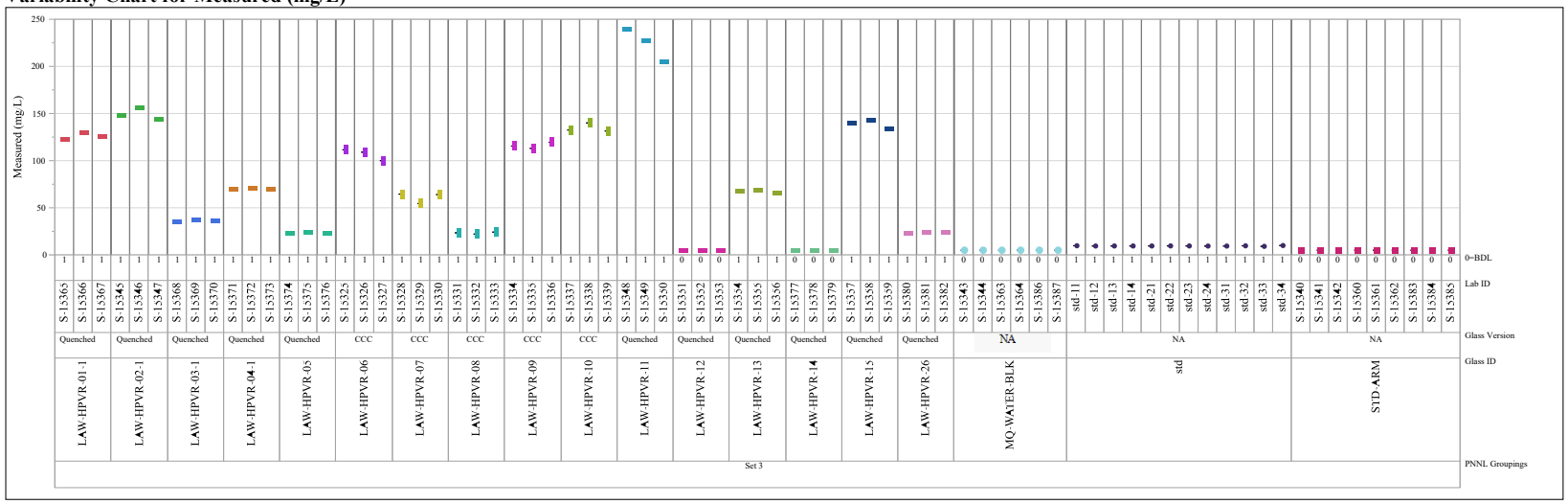
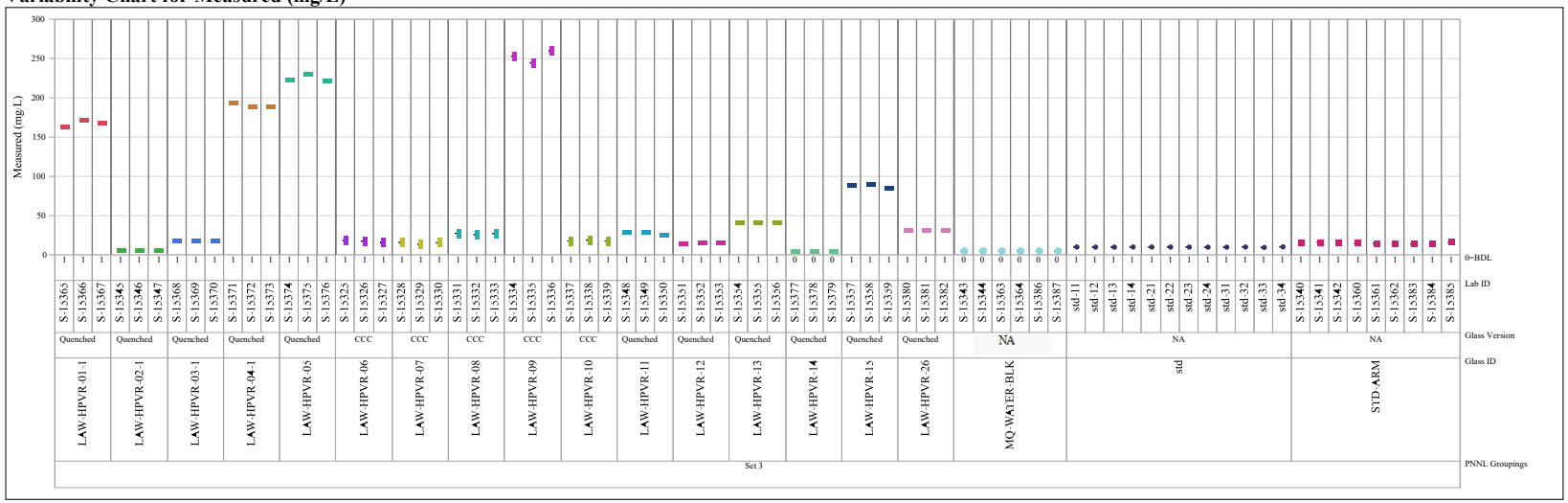


Exhibit A-1. PCT Measurements by Glass ID by PNNL Groupings (continued)

Analyte=Li
Variability Chart for Measured (mg/L)



Analyte=Na
Variability Chart for Measured (mg/L)

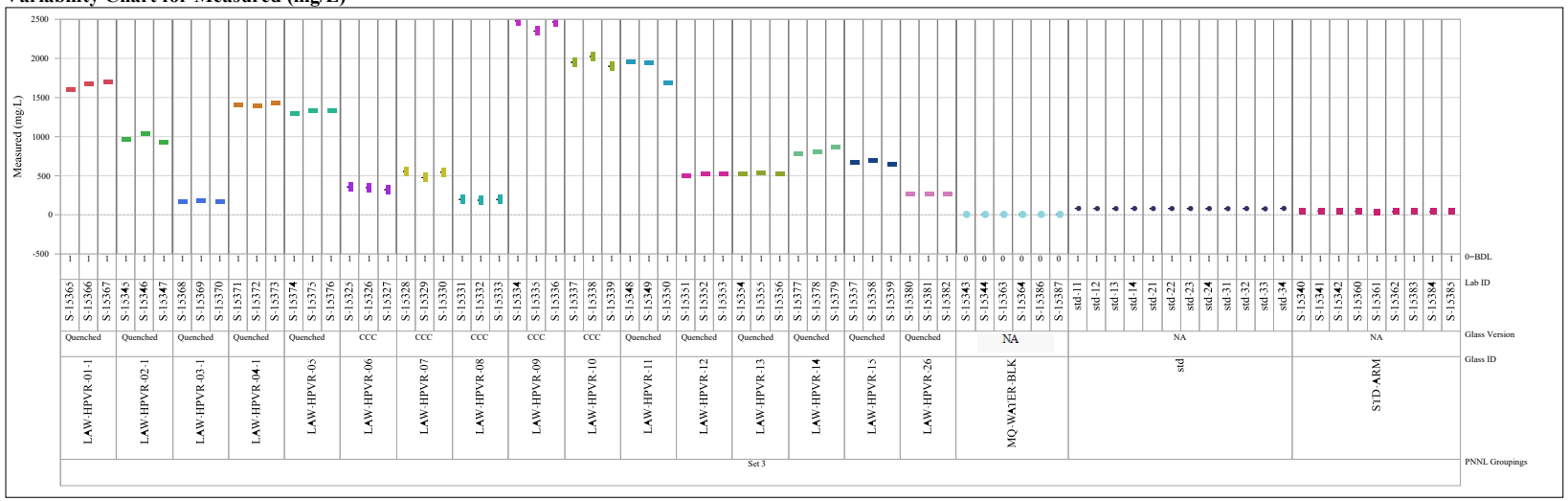
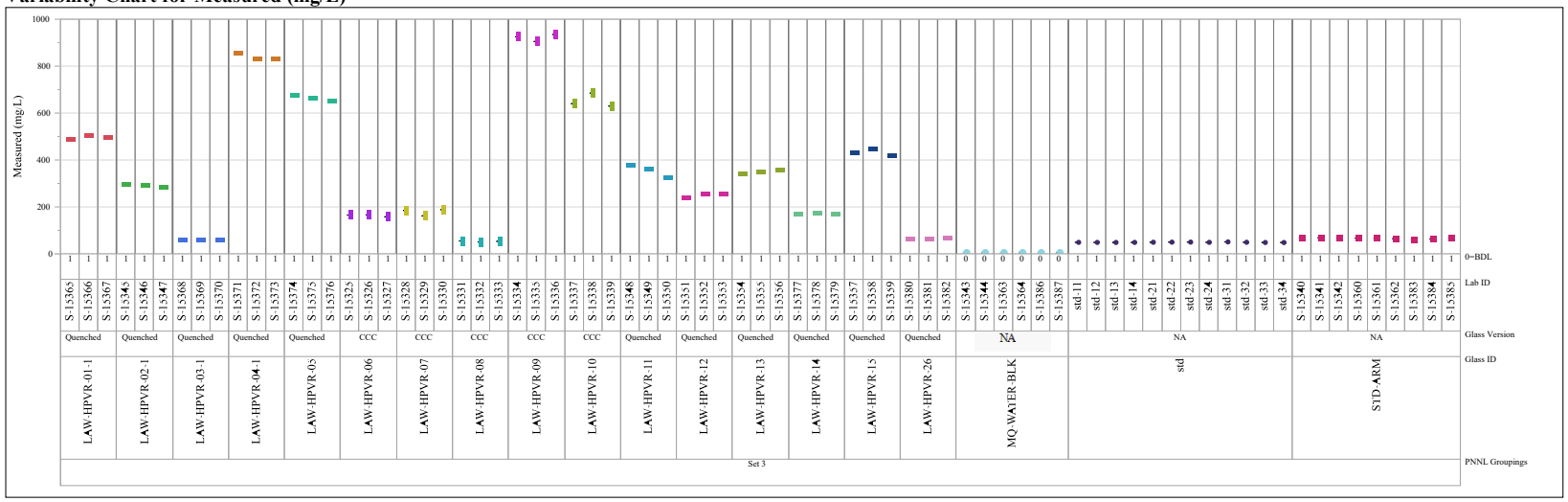
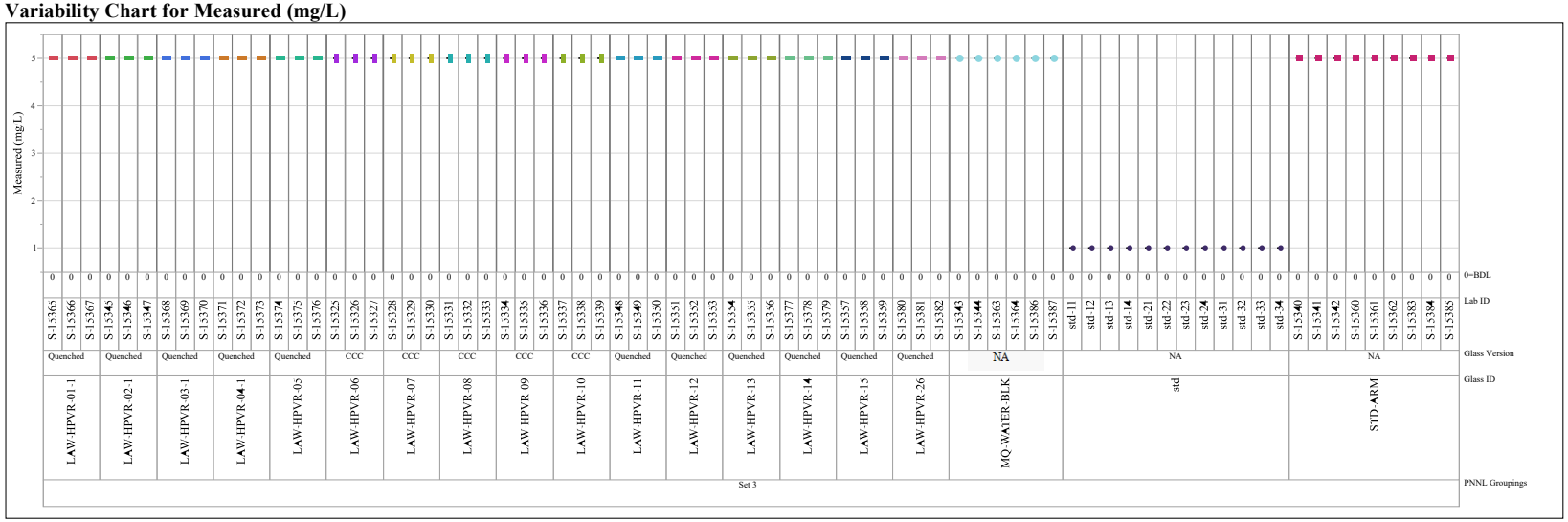


Exhibit A-1. PCT Measurements by Glass ID by PNNL Groupings (continued)

Analyte=Si
Variability Chart for Measured (mg/L)



Analyte=Zr
Variability Chart for Measured (mg/L)



Appendix B. Normalized PCT Results

Table B-1. Normalized PCT Results (g/L) for Selected Elements

Glass ID	PNNL Group	Comp. View	NC_B	NC_{Li}	NC_{Na}	NC_{Si}
LAW-HPVR-01-1-CCC	CCC	Target	14.3	13.6	12.3	2.57
LAW-HPVR-01-1-CCC	CCC	Measured	14.5	13.5	12.8	2.61
LAW-HPVR-01-1-Q	Q	Target	13.9	13.2	12.2	2.57
LAW-HPVR-01-1-Q	Q	Measured	14.1	13.1	12.8	2.61
LAW-HPVR-01-1-Q	Set 3	Target	15.2	13.8	12.3	2.65
LAW-HPVR-01-1-Q	Set 3	Measured	15.5	13.7	12.8	2.69
LAW-HPVR-02-1-CCC	CCC	Target	9.09	9.32	8.79	1.61
LAW-HPVR-02-1-CCC	CCC	Measured	9.51	10.1	9.49	1.68
LAW-HPVR-02-1-Q	Q	Target	9.09	9.00	9.66	1.61
LAW-HPVR-02-1-Q	Q	Measured	9.51	9.76	10.4	1.68
LAW-HPVR-02-1-Q	Set 3	Target	7.90	7.20	7.44	1.50
LAW-HPVR-02-1-Q	Set 3	Measured	8.27	7.80	8.03	1.57
LAW-HPVR-03-1-CCC	CCC	Target	1.13	1.33	1.41	0.336
LAW-HPVR-03-1-CCC	CCC	Measured	1.21	1.45	1.42	0.354
LAW-HPVR-03-1-Q	Q	Target	1.36	1.45	1.66	0.36
LAW-HPVR-03-1-Q	Q	Measured	1.46	1.58	1.67	0.38
LAW-HPVR-03-1-Q	Set 3	Target	1.21	1.35	1.46	0.349
LAW-HPVR-03-1-Q	Set 3	Measured	1.29	1.48	1.46	0.368
LAW-HPVR-04-1-CCC	CCC	Target	10.1	9.77	9.22	3.13
LAW-HPVR-04-1-CCC	CCC	Measured	10.3	9.80	9.85	3.20
LAW-HPVR-04-1-Q	Q	Target	15.7	15.0	13.4	3.90
LAW-HPVR-04-1-Q	Q	Measured	16.0	15.1	14.3	3.98
LAW-HPVR-04-1-Q	Set 3	Target	13.8	12.2	11.0	3.91
LAW-HPVR-04-1-Q	Set 3	Measured	14.1	12.2	11.8	3.99
LAW-HPVR-05-CCC	CCC	Target	9.08	8.43	7.10	2.46
LAW-HPVR-05-CCC	CCC	Measured	9.52	9.29	7.44	2.58
LAW-HPVR-05-Q	Q	Target	13.8	12.3	11.3	3.09
LAW-HPVR-05-Q	Q	Measured	14.5	13.6	11.8	3.22
LAW-HPVR-05-Q	Set 3	Target	13.6	11.7	10.1	3.23
LAW-HPVR-05-Q	Set 3	Measured	14.2	12.9	10.5	3.38
LAW-HPVR-06-CCC	CCC	Target	2.41	3.06	2.96	0.837
LAW-HPVR-06-CCC	CCC	Measured	2.41	3.04	2.98	0.837
LAW-HPVR-06-Q	Q	Target	3.57	4.07	4.17	1.10
LAW-HPVR-06-Q	Q	Measured	3.57	4.04	4.20	1.10
LAW-HPVR-06-CCC	Set 3	Target	2.57	2.91	2.90	0.851
LAW-HPVR-06-CCC	Set 3	Measured	2.57	2.89	2.92	0.851
LAW-HPVR-07-CCC	CCC	Target	3.41	3.75	3.70	1.07
LAW-HPVR-07-CCC	CCC	Measured	3.46	3.57	4.18	1.07
LAW-HPVR-07-Q	Q	Target	4.47	4.56	5.21	1.30
LAW-HPVR-07-Q	Q	Measured	4.55	4.34	5.89	1.29
LAW-HPVR-07-CCC	Set 3	Target	3.15	3.21	3.36	1.01
LAW-HPVR-07-CCC	Set 3	Measured	3.21	3.06	3.80	1.00
LAW-HPVR-08-CCC	CCC	Target	1.73	1.64	1.70	0.333
LAW-HPVR-08-CCC	CCC	Measured	1.71	1.64	1.79	0.327
LAW-HPVR-08-Q	Q	Target	2.04	1.85	2.01	0.382
LAW-HPVR-08-Q	Q	Measured	2.00	1.84	2.12	0.375

Table B-1. Normalized PCT Results (g/L) for Selected Elements (continued)

Glass ID	PNNL Group	Comp. View	NC_B	NC_{Li}	NC_{Na}	NC_{Si}
LAW-HPVR-08-CCC	Set 3	Target	1.71	1.65	1.59	0.322
LAW-HPVR-08-CCC	Set 3	Measured	1.68	1.65	1.68	0.316
LAW-HPVR-09-CCC	CCC	Target	21.0	18.5	17.4	4.01
LAW-HPVR-09-CCC	CCC	Measured	21.3	18.6	18.0	4.07
LAW-HPVR-09-Q	Q	Target	25.7	22.8	21.5	4.79
LAW-HPVR-09-Q	Q	Measured	26.1	22.9	22.3	4.85
LAW-HPVR-09-CCC	Set 3	Target	21.9	19.2	17.2	4.53
LAW-HPVR-09-CCC	Set 3	Measured	22.2	19.3	17.8	4.60
LAW-HPVR-10-CCC	CCC	Target	14.1	13.2	13.4	3.51
LAW-HPVR-10-CCC	CCC	Measured	14.1	12.8	13.6	3.52
LAW-HPVR-10-Q	Q	Target	18.2	16.8	17.6	4.21
LAW-HPVR-10-Q	Q	Measured	18.2	16.3	17.8	4.23
LAW-HPVR-10-CCC	Set 3	Target	12.9	11.5	11.6	3.41
LAW-HPVR-10-CCC	Set 3	Measured	12.9	11.1	11.7	3.43
LAW-HPVR-11-CCC	CCC	Target	11.6	9.63	9.38	1.90
LAW-HPVR-11-CCC	CCC	Measured	12.2	10.3	9.64	1.97
LAW-HPVR-11-Q	Q	Target	14.1	11.7	12.1	2.11
LAW-HPVR-11-Q	Q	Measured	14.7	12.5	12.5	2.20
LAW-HPVR-11-Q	Set 3	Target	14.4	11.7	11.2	2.14
LAW-HPVR-11-Q	Set 3	Measured	15.1	12.5	11.5	2.23
LAW-HPVR-12-CCC	CCC	Target	1.87	2.05	2.76	1.01
LAW-HPVR-12-CCC	CCC	Measured	1.90	2.07	2.83	1.03
LAW-HPVR-12-Q	Q	Target	2.31	1.96	3.53	1.23
LAW-HPVR-12-Q	Q	Measured	2.35	1.98	3.62	1.26
LAW-HPVR-12-Q	Set 3	Target	2.11	1.79	3.01	1.11
LAW-HPVR-12-Q	Set 3	Measured	2.15	1.81	3.09	1.13
LAW-HPVR-13-CCC	CCC	Target	3.69	3.73	3.50	1.31
LAW-HPVR-13-CCC	CCC	Measured	3.69	3.73	3.60	1.31
LAW-HPVR-13-Q	Q	Target	4.77	4.78	4.49	1.61
LAW-HPVR-13-Q	Q	Measured	4.77	4.78	4.63	1.61
LAW-HPVR-13-Q	Set 3	Target	4.67	4.55	4.20	1.53
LAW-HPVR-13-Q	Set 3	Measured	4.67	4.55	4.33	1.53
LAW-HPVR-14-CCC	CCC	Target	3.69	<4.68	4.06	0.956
LAW-HPVR-14-CCC	CCC	Measured	3.73	<4.56	4.22	0.962
LAW-HPVR-14-Q	Q	Target	4.29	<4.68	4.67	1.10
LAW-HPVR-14-Q	Q	Measured	4.33	<4.56	4.85	1.10
LAW-HPVR-14-Q	Set 3	Target	4.22	<4.68	4.21	1.04
LAW-HPVR-14-Q	Set 3	Measured	4.26	<4.56	4.37	1.04
LAW-HPVR-15-CCC	CCC	Target	5.09	5.03	4.66	1.69
LAW-HPVR-15-CCC	CCC	Measured	5.34	5.39	5.04	1.79
LAW-HPVR-15-Q	Q	Target	6.41	6.24	6.17	2.03
LAW-HPVR-15-Q	Q	Measured	6.73	6.69	6.68	2.14
LAW-HPVR-15-Q	Set 3	Target	6.49	6.06	5.74	2.01
LAW-HPVR-15-Q	Set 3	Measured	6.81	6.49	6.21	2.12
LAW-HPVR-16-CCC	CCC	Target	2.37	2.31	2.20	0.459
LAW-HPVR-16-CCC	CCC	Measured	2.41	2.26	2.38	0.458
LAW-HPVR-16-Q	Q	Target	3.49	2.61	3.07	0.613
LAW-HPVR-16-Q	Q	Measured	3.55	2.55	3.32	0.612

Table B-1. Normalized PCT Results (g/L) for Selected Elements (continued)

Glass ID	PNNL Group	Comp. View	NC_B	NC_{Li}	NC_{Na}	NC_{Si}
LAW-HPVR-17-CCC	CCC	Target	1.36	1.64	1.60	0.356
LAW-HPVR-17-CCC	CCC	Measured	1.44	1.76	1.74	0.372
LAW-HPVR-17-Q	Q	Target	1.43	1.48	1.75	0.406
LAW-HPVR-17-Q	Q	Measured	1.51	1.59	1.91	0.424
LAW-HPVR-18-CCC	CCC	Target	7.06	7.25	6.78	1.46
LAW-HPVR-18-CCC	CCC	Measured	7.46	7.81	7.22	1.53
LAW-HPVR-18-Q	Q	Target	9.24	9.61	9.04	1.77
LAW-HPVR-18-Q	Q	Measured	9.77	10.4	9.63	1.86
LAW-HPVR-19-CCC	CCC	Target	1.53	1.84	2.23	0.776
LAW-HPVR-19-CCC	CCC	Measured	1.55	1.86	2.25	0.792
LAW-HPVR-19-Q	Q	Target	1.69	1.66	2.50	0.85
LAW-HPVR-19-Q	Q	Measured	1.71	1.68	2.52	0.868
LAW-HPVR-20-CCC	CCC	Target	36.4	27.5	29.7	7.72
LAW-HPVR-20-CCC	CCC	Measured	36.7	27.0	31.0	7.77
LAW-HPVR-20-Q	Q	Target	52.8	37.4	46.4	10.3
LAW-HPVR-20-Q	Q	Measured	53.2	36.8	48.5	10.4
LAW-HPVR-21-CCC	CCC	Target	3.31	<12.5	3.05	0.453
LAW-HPVR-21-CCC	CCC	Measured	3.53	<9.97	3.13	0.478
LAW-HPVR-21-Q	Q	Target	4.04	<12.5	3.70	0.501
LAW-HPVR-21-Q	Q	Measured	4.31	<9.97	3.79	0.528
LAW-HPVR-22-CCC	CCC	Target	1.72	2.00	2.10	0.599
LAW-HPVR-22-CCC	CCC	Measured	1.77	1.99	2.13	0.607
LAW-HPVR-22-Q	Q	Target	1.76	1.51	2.19	0.591
LAW-HPVR-22-Q	Q	Measured	1.82	1.51	2.21	0.6
LAW-HPVR-23-CCC	CCC	Target	2.47	2.25	2.77	0.878
LAW-HPVR-23-CCC	CCC	Measured	2.58	2.38	2.92	0.907
LAW-HPVR-23-Q	Q	Target	3.36	2.12	3.57	1.09
LAW-HPVR-23-Q	Q	Measured	3.50	2.24	3.77	1.12
LAW-HPVR-24-CCC	CCC	Target	8.74	8.30	8.08	2.58
LAW-HPVR-24-CCC	CCC	Measured	9.08	8.45	8.34	2.62
LAW-HPVR-24-Q	Q	Target	13.3	11.5	11.7	3.25
LAW-HPVR-24-Q	Q	Measured	13.9	11.7	12.0	3.31
LAW-HPVR-25-CCC	CCC	Target	12.2	14.2	18.4	1.52
LAW-HPVR-25-CCC	CCC	Measured	12.6	13.6	20.7	1.51
LAW-HPVR-25-Q	Q	Target	5.49	5.03	5.73	1.82
LAW-HPVR-25-Q	Q	Measured	5.67	4.80	6.46	1.81
LAW-HPVR-26-CCC	CCC	Target	2.63	2.41	2.22	0.504
LAW-HPVR-26-CCC	CCC	Measured	2.67	2.39	2.46	0.498
LAW-HPVR-26-Q	Q	Target	2.16	1.95	2.2	0.409
LAW-HPVR-26-Q	Q	Measured	2.19	1.93	2.44	0.404
LAW-HPVR-26-Q	Set 3	Target	2.12	1.90	2.04	0.390
LAW-HPVR-26-Q	Set 3	Measured	2.15	1.88	2.26	0.385
LRM-CCC	CCC	Reference	1.13	<9.79	1.11	0.305
LRM-Q	Q	Reference	1.12	<9.79	1.13	0.319
ARM-S3	Set 3	Reference	0.577	0.635	0.598	0.303

Exhibit B-1. Normalized PCT Results by Glass Version by Compositional View for Each Glass

Variability Chart for NC_{Al} (g/L)

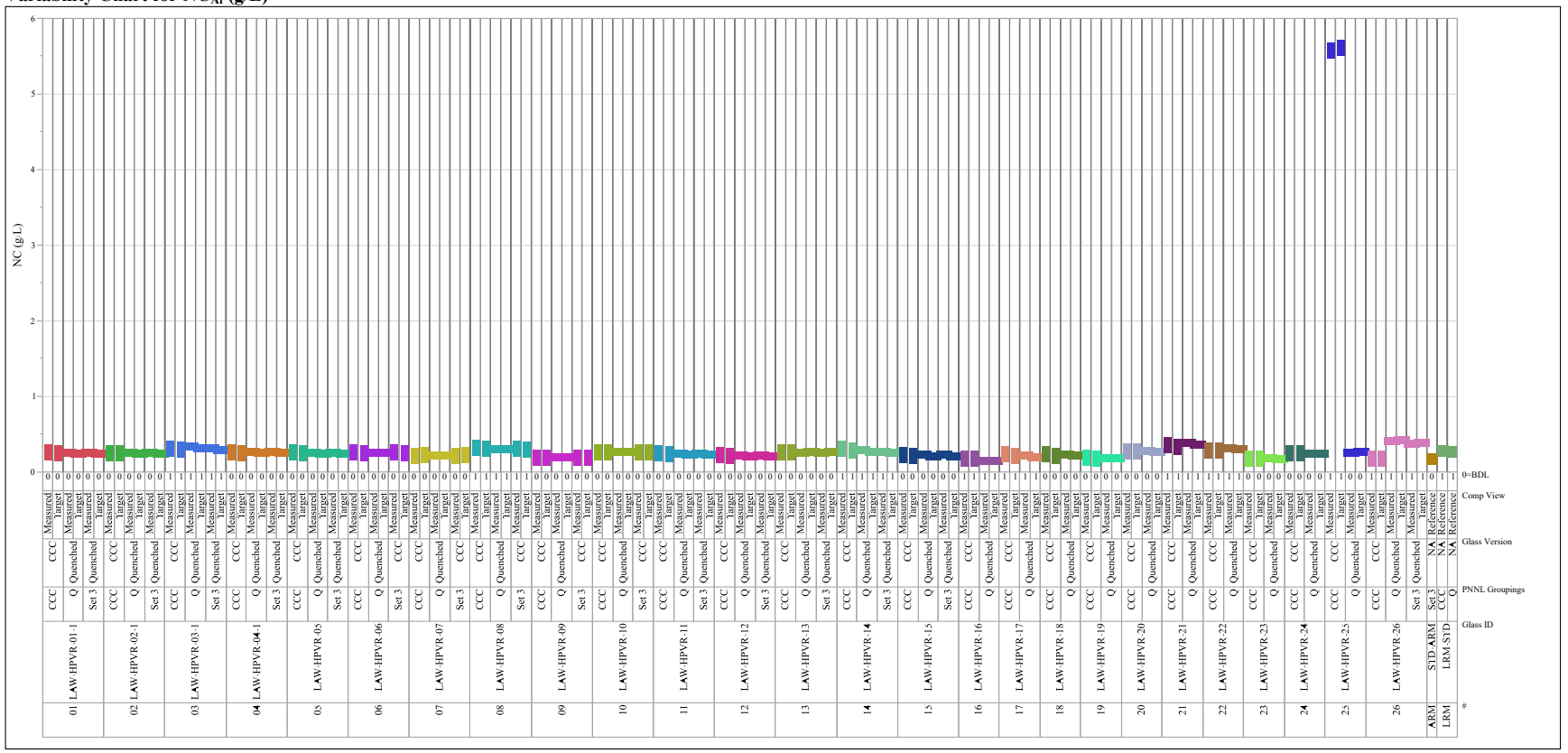


Exhibit B-1. Normalized PCT Results by Glass Version by Compositional View for Each Glass (continued)

Variability Chart for NC_B (g/L)

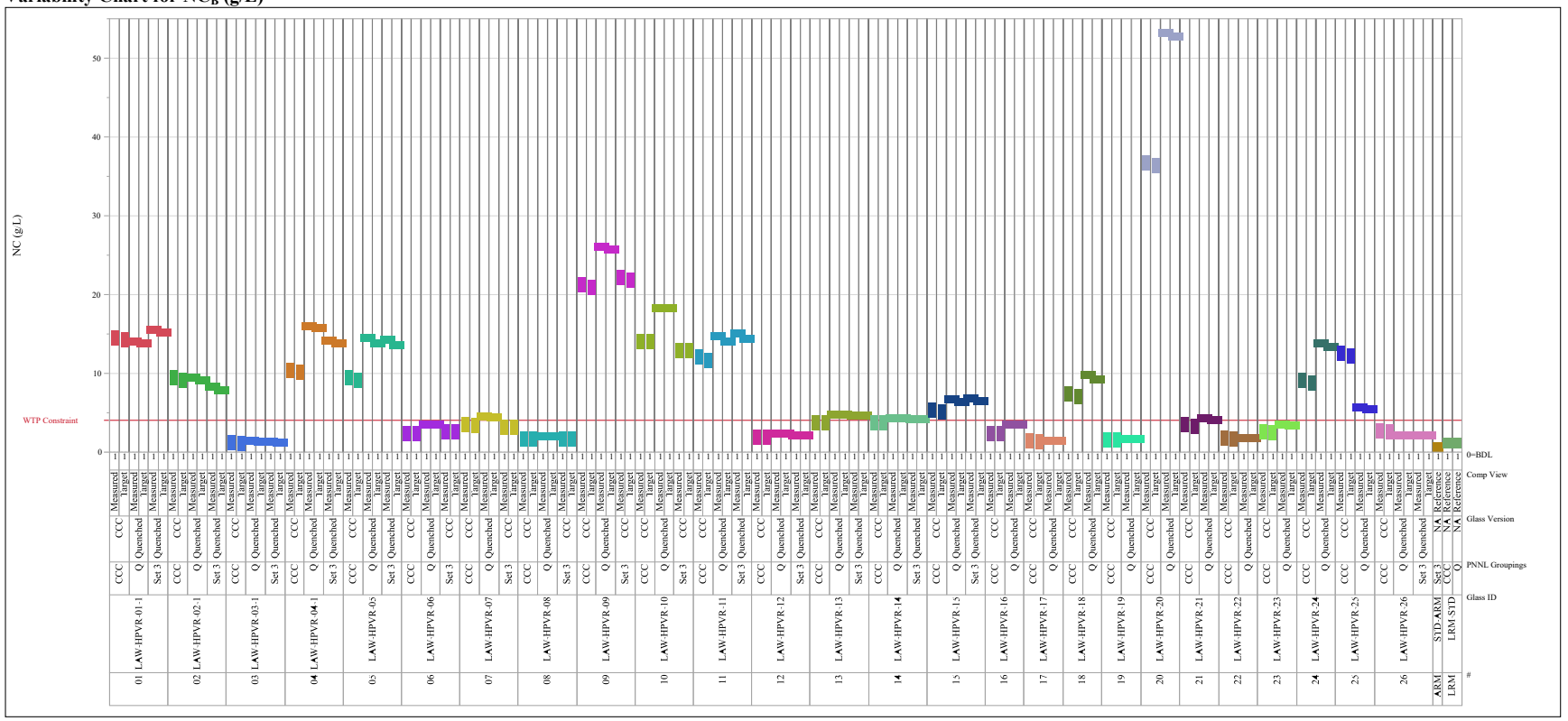


Exhibit B-1. Normalized PCT Results by Glass Version by Compositional View for Each Glass (continued)

Variability Chart for NC_K (g/L)

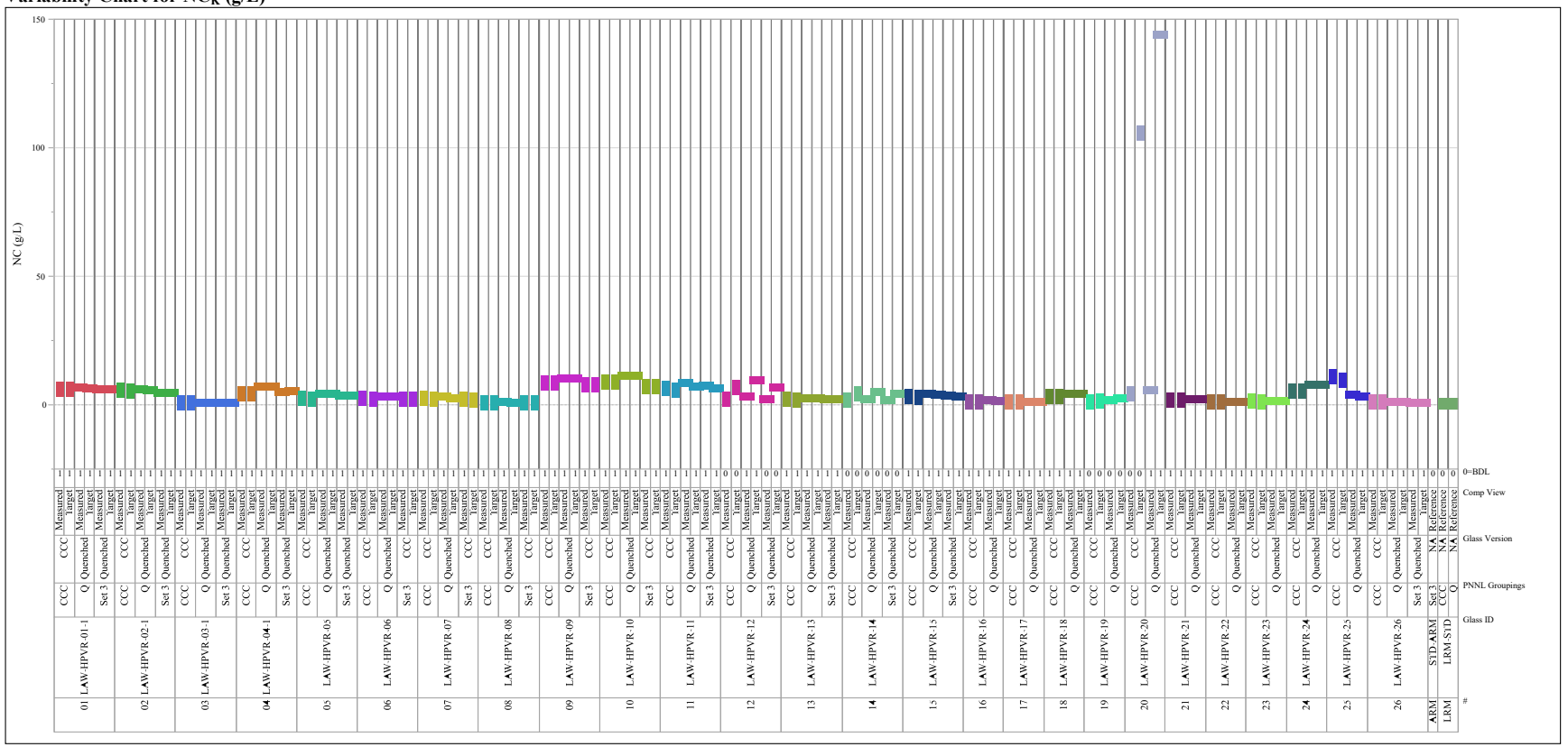


Exhibit B-1. Normalized PCT Results by Glass Version by Compositional View for Each Glass (continued)

Variability Chart for NC_{Li} (g/L)

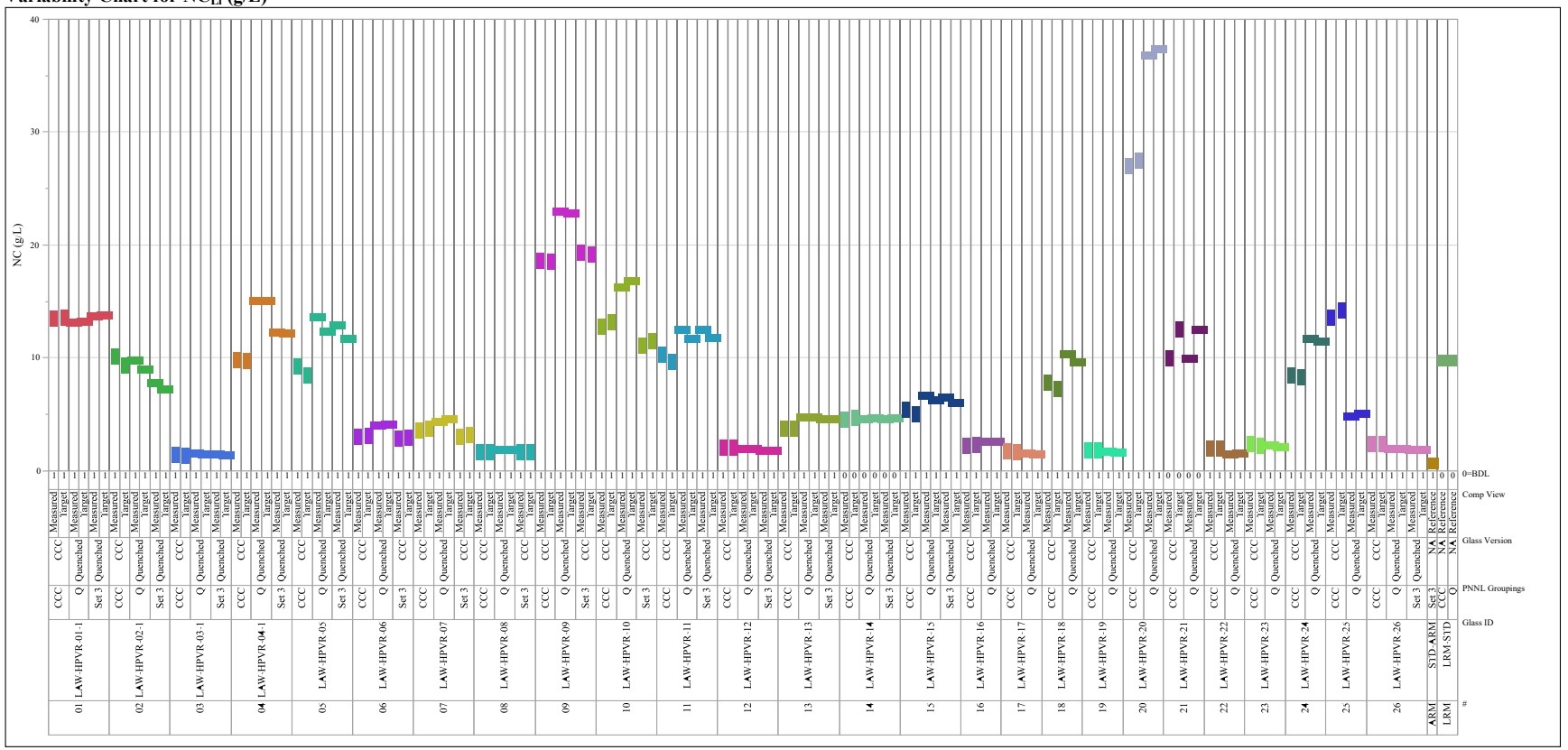


Exhibit B-1. Normalized PCT Results by Glass Version by Compositional View for Each Glass (continued)

Variability Chart for NC_{Na} (g/L)

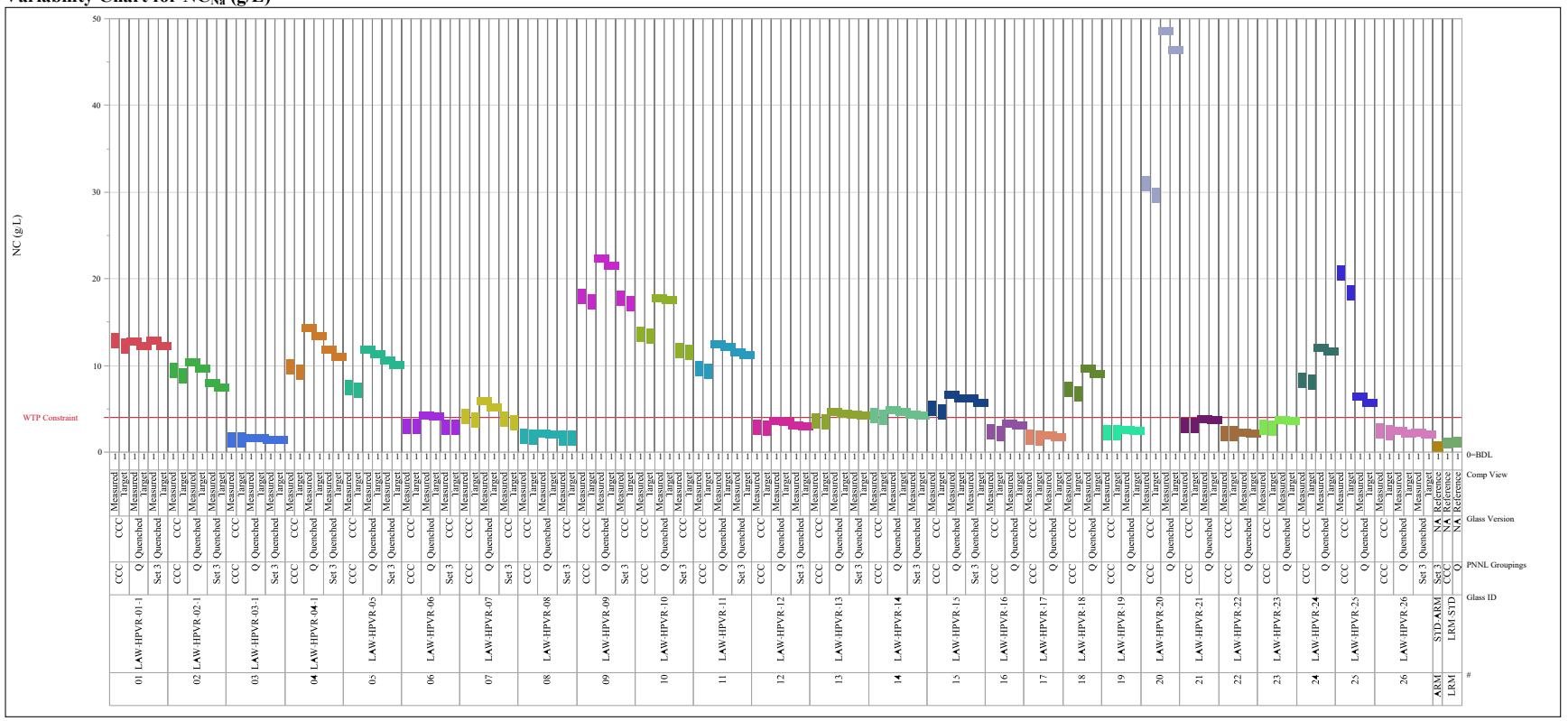
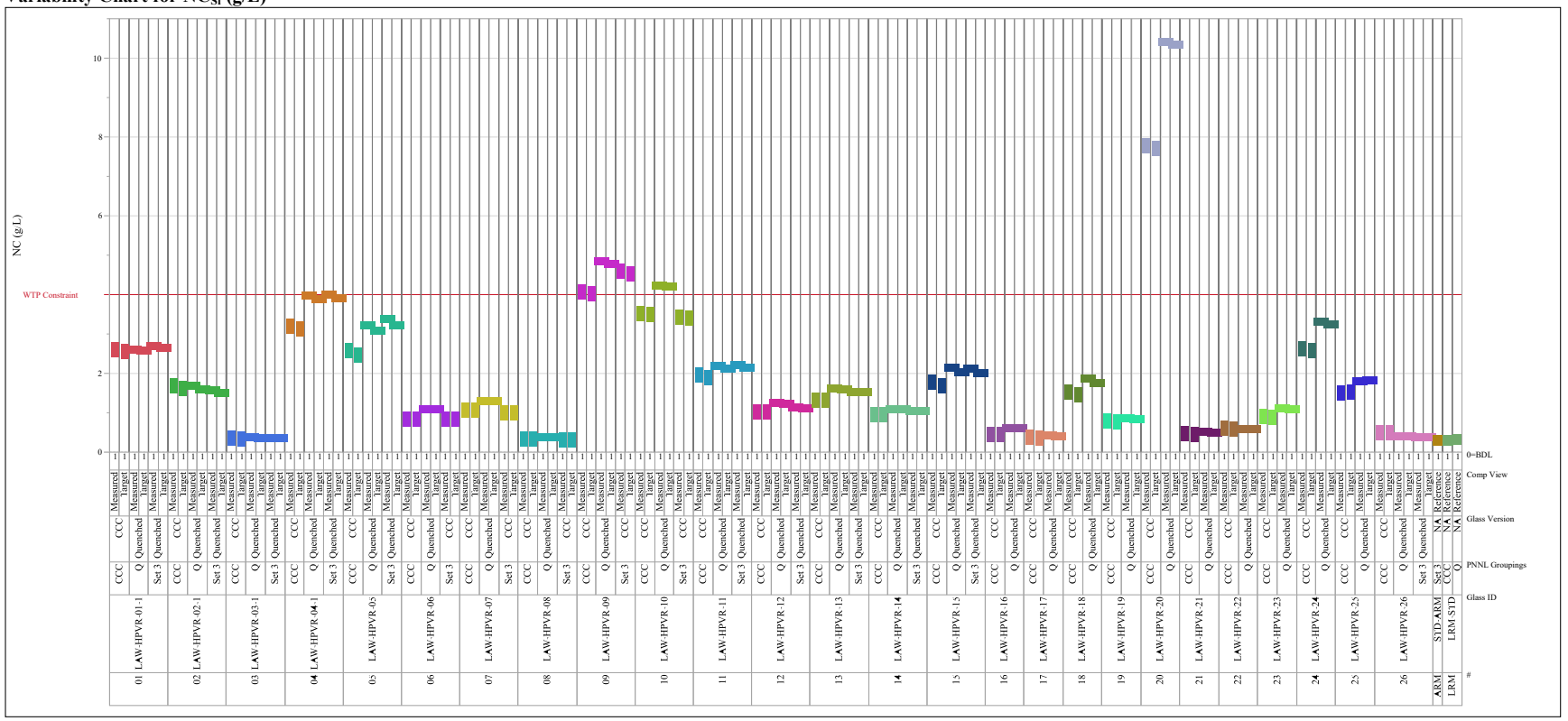


Exhibit B-1. Normalized PCT Results by Glass Version by Compositional View for Each Glass (continued)

Variability Chart for NC_{Si} (g/L)



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