DEPARTMENT OF FORENSIC SCIENCE
METHOD VALIDATION SUMMARY FORM

Section: Controlled Substances

Method: Quantitative Analysis of Cocaine, Heroin, and Methamphetamine using a Multipoint Calibration Curve

Results recorded? ✔

Procedure documented? ✔

Method fit for use? ✔

Approved by: Robyn Weimer Date: 03/25/2026

Executive Validation Summary: "Quantitative Analysis of Cocaine, Heroin, and Methamphetamine using a Multipoint Calibration Curve"

Recommended Uses:

This validation indicates that a multipoint calibration curve is a viable means of quantitatively analyzing cocaine, heroin, and methamphetamine. With a calibration range of 0.05 mg/mL – 0.5 mg/mL, samples above the range can be diluted 1:2 or 1:5 while maintaining acceptable bias and precision. A calibration model of linear unweighted was determined to be the best fit for cocaine while a linear weighted (1/x) calibration model was determined to be the best fit for heroin and methamphetamine.

Limitations:

Due to the coelution of chromatographic peaks, heroin samples containing hydromorphone and methamphetamine samples containing aspirin are unsuitable for quantitative analysis using a multipoint calibration curve.

Samples containing compounds not included on the interferences list are unsuitable for quantitative analysis until they have been verified to not impact response of the target analyte and/or internal standard.

Because stability studies were not performed, new calibration and control stocks must be prepared prior to analysis.

Information Provided:

- Reagents and Sample Preparation
- Summary of Results and Conclusions

Studies Performed:

- Bias and Precision
- Lower Limit of Quantitation (LLOQ)
- Linearity and Calibration Model
- Recovery
- Interferences
- Dilution Integrity

RBW

03/25/2026

Memo To: Robyn Weimer, Chemistry Program Manager
From: Rebecca Wagner, Ph.D., Chemistry Research Section Supervisor
CC: Alka Lohmann, Director of Technical Services
Date: March 23, 2026
RE: Validation Summary
Quantitative Analysis of Cocaine, Heroin, and Methamphetamine using a Multipoint Calibration Curve

Validation Summary – Quantitative Analysis of Cocaine, Heroin, and Methamphetamine using a Multipoint Calibration Curve

The validation of a multipoint calibration curve for the quantitative analysis of cocaine, heroin, and methamphetamine was conducted pursuant to the validation plan with alterations. In 2021, the Central Laboratory Controlled Substances Section began work on this project. The initial plan was to use the existing data and perform additional validation experiments in the Chemistry Research Section to meet current validation requirements.

The additional validation experiments were completed using the same parameters and non-zero calibrators used in 2021. Due to poor peak shape and the presence of instrumental carryover, it was determined that the calibration range (0.5 – 5.0 mg/mL) was not fit for purpose. Therefore, the calibration range was shifted ten-fold to 0.05 – 0.5 mg/mL. In addition to improving chromatography, this lower calibration range (0.05 – 0.5 mg/mL) also expanded the purity reporting range for the target compounds. Since samples are prepared by weighing 20 mg of sample in 10 mL of internal standard, the maximum concentration a sample can have is 2 mg/mL, assuming 100% purity. The previously evaluated calibration range of 0.5 – 5.0 mg/mL only allowed for the reporting of purities 25% and greater, as any sample less than 25% would be below the calibration curve. By changing the calibration range to 0.05 – 0.5 mg/mL, purities 2.5% and greater can be reported, with purities greater than 25% requiring dilution to be within the calibration range.

Due to the change in calibration range, the initial work performed in 2021 could not be utilized. Therefore, all validation experiments were repeated using the calibration range of 0.05 – 0.5 mg/mL. Each day of analysis, aliquots of a calibration stock (5.0 mg/mL) and a control stock (9.0 mg/mL) were diluted ten-fold to create the working calibration solution (0.5 mg/mL) and the working control solution (0.9 mg/mL). These working solutions were then used to prepare the calibrators and controls listed in Table 1.

Table 1: Concentration of calibrators and controls

Name	Concentration	Volume of Working Solution (µL)	Volume of Internal Standard (µL)
Calibrator 1	0.05 mg/mL	20	180
Calibrator 2	0.10 mg/mL	40	160
Calibrator 3	0.20 mg/mL	80	120
Calibrator 4	0.30 mg/mL	120	80
Calibrator 5	0.40 mg/mL	160	40
Calibrator 6	0.50 mg/mL	200	0
Control 1	0.15 mg/mL	25	125
Control 2	0.30 mg/mL	50	100
Control 3	0.45 mg/mL	75	75

Stock solutions were prepared by weighing solid material and dissolving in internal standard, but the final concentrations did not match those listed above. The true concentrations of solutions based on the amount of solid weighed and purity reported on the standard's certificate of analysis, were used to create the calibration curves and for data analysis by updating the concentrations in MassHunter.

Samples were analyzed on an Agilent Technologies 8890 gas chromatograph with a flame ionization detector (GC-FID). Sample preparation and analysis were performed in accordance with the Controlled Substances Procedures Manual (Qualtrax Revision 24). The instrumental parameters for each method are listed in the Supplemental Information (Table S1). The validation included the following studies:

1. Bias and Precision
2. Lower Limit of Quantitation (LLOQ)
3. Linearity and Calibration Model
4. Recovery
5. Interferences
6. Stability
7. Dilution Integrity

All data from the validation has been stored on the DX Validation SharePoint and can also be accessed on the Chemistry Research Instrument Network.

1. Bias and Precision

Bias and precision were assessed by evaluating calibrators, controls, and authentic powder material. Authentic material consisted of in-house training samples. Although prepared using the same solid standards as the calibration curve, controls were prepared by a secondary individual. Authentic material was prepared in accordance with the Controlled Substances Procedures Manual (Qualtrax Revision 24, §18.11, §19.8, and §21.8). For each sample, six replicates were prepared by extracting 20 mg of powder into 10 mL of internal standard. These replicates were analyzed using the existing, historical calibration curve to establish the "known" concentration. Based on the concentrations obtained from the historical calibration curve, the samples were then analyzed using the multipoint calibration curve either undiluted, with a two-fold dilution, or with a five-fold dilution.

a. Bias

Bias was assessed at three different concentrations (0.15 mg/mL, 0.30 mg/mL, and 0.45 mg/mL) over five analytical runs of independently prepared calibration curves and controls. Each analytical run, the controls were run in singlet. The bias was calculated using Equation 1.

Equation 1

$$Bias\ (\%)\ Concentration_x = \left(\frac{Mean\ of\ Calculated\ Concentration_x - Expected\ Concentration_x}{Expected\ Concentration_x}\right) \times 100$$

Bias within ±10% was considered acceptable. Additionally, where available, bias was assessed utilizing authentic powder material. Each specimen was analyzed following the historical calibration curve methodology to establish the percent purity and associated measurement uncertainty (Table S2). The specimens were then analyzed with six replicates over five analytical runs using the multipoint calibration curve. The average of the six replicate values was calculated and the bias was considered acceptable if the bias was within ±10% of the "known" concentration or if the average concentration fell within the range established by the historical calibration curve method.

To establish the bias within the run, the average bias was calculated for each control and authentic material for each of the five analytical runs. For authentic material, the calculated concentrations of the six replicates were converted to percent purity and averaged. The average purity was compared to the "known" purity uncertainty of measurement range. The bias was acceptable for controls and authentic material (Table 2 - Table 4).

Table 2: Percent bias of cocaine controls and authentic materials

Sample	Dilution	Bias (%)				
		Day 1	Day 2	Day 3	Day 4	Day 5
Control 1	---	-4.28	1.94	5.41	-7.66	5.88
Control 2	---	-7.59	1.55	5.72	-7.97	9.02
Control 3	---	-2.07	-0.82	6.27	-7.61	9.53
TST-2	5x	-2.46	-4.62	-2.17	-8.12	-4.99
TSC-4	5x	1.19	0.25	-0.06	-5.51	-0.53

Table 3: Percent bias of heroin controls and authentic materials

Sample	Dilution	Bias (%)				
		Day 1	Day 2	Day 3	Day 4	Day 5
Control 1	---	1.72	-4.70	-0.75	4.75	-7.55
Control 2	---	-6.05	0.36	-4.12	3.51	-2.79
Control 3	---	0.41	-8.25	-1.75	8.12	-2.68
TSW-242	5x	0.41	4.11	0.85	3.21	0.82
TSC-284	5x	-1.53	1.05[a]	-2.92	-1.43	-2.74
TSC-751	1x	-4.81	-0.91	-1.19	1.22	-1.40
TSC-906	5x	-3.46	-0.95	-3.10	-3.39	-2.37

[a] Excludes one replicate due to being an outlier

Table 4: Percent bias of methamphetamine controls and authentic materials

Sample	Dilution	Bias (%)				
		Day 1	Day 2	Day 3	Day 4	Day 5
Control 1	---	2.97	-5.31	-7.61	0.26	-0.21
Control 2	---	4.35	-8.49	-7.53	-0.26	6.35
Control 3	---	8.92	-3.79	-7.49	0.97	3.00
TSW-471	5x	1.36	5.19	7.26	2.02	11.84[a]
TSC-1	5x	3.30	0.30	6.21	1.16	8.54
TSC-2	5x	1.76	2.59	5.89	-0.83	4.54
TSW-469	5x	5.07	8.42	8.37	6.94	3.32
TSW-468	5x	5.81	-5.80	3.87	2.50	3.42

[a] Excludes two replicates due to being above the calibration curve

Although the bias of TSW-471 on Day 5 is outside the criterion of ±10%, the average purity (114.8%) falls within the range established by the historical calibration curve method (102.6 ± 13.6%) and is therefore considered acceptable.

b. Precision

Precision of the method was assessed by calculating the percent coefficient of variation (%CV) using Equation 2. The same data obtained for bias experiments was used for the evaluation of precision. The %CV shall be less than 10% to be considered acceptable.

Equation 2

$$\%CV = \frac{Standard\ deviation\ of\ combined\ means}{Calculated\ grand\ mean} \times 100$$

The precision was calculated for each authentic powder specimen analyzed from each of the five analytical runs. The precision was acceptable for all authentic powder specimens (Table 5).

Table 5: Precision of authentic materials

Analyte	Sample	Dilution	Precision (%)				
			Day 1	Day 2	Day 3	Day 4	Day 5
Cocaine	TST-2	5x	5.59	5.38	4.64	4.58	4.19
	TSC-4	5x	3.24	1.59	3.45	4.06	1.94
Heroin	TSW-242	5x	2.56	3.17	2.56	3.53	4.01
	TSC-284	5x	3.20	3.59[a]	4.64	6.31	1.31
	TSC-751	1x	2.88	4.59	3.71	3.99	4.09
	TSC-906	5x	2.03	3.08	2.13	3.42	1.36
Methamphetamine	TSW-471	5x	6.15	6.34	2.14	2.70	3.69[b]
	TSC-1	5x	1.96	4.13	1.90	3.44	6.06
	TSC-2	5x	4.18	3.81	1.19	1.79	4.34
	TSW-469	5x	5.79	4.43	2.85	4.54	2.55
	TSW-468	5x	1.81	3.13	1.49	2.03	2.45

[a] Excludes one replicate due to being an outlier

[b] Excludes two replicates due to being above the calibration curve

2. Lower Limit of Quantitation (LLOQ)

The lower limit of quantitation was established by evaluating the lowest non-zero calibrator (0.05 mg/mL) from each calibration curve. The bias shall be within ±10% of the target concentration, the retention time shall be within 0.033 minutes of the certified reference material retention time, the signal-to-noise ratio shall be greater than 10, and the peak shape shall be symmetrical. All cocaine, heroin, and methamphetamine 0.05 mg/mL calibrator samples passed the predetermined acceptance criteria.

3. Linearity and Calibration Model

To establish the calibration model, six calibration curves analyzed over different analytical runs were utilized. For each replicate, the origin was ignored. Residual analysis and statistical comparisons between linear unweighted, linear weighted (1/x), quadratic non-weighted, and quadratic weighted (1/x) were conducted to establish the simplest model that best fit the data.

To determine whether the model was linear or quadratic in nature, ANOVA was used to compare the standard deviation of the residuals using both the t-test and the f-test. For the t-test, if the p-value <0.05, the null hypothesis was rejected, indicating a statistically significant difference between groups. For the f-test, if $f > F_{crit}$, the null hypothesis was rejected, indicating a statistically significant difference in the variance between the groups. If the two groups were determined not

to be statistically different, a linear calibration model was applied. If the two groups were determined to be statistically different, a quadratic calibration model was applied.

To determine the weighting of the calibration model, unweighted or weighted (1/x), a t-test was used to compare the sum of the relative error for the residual. If the p-value <0.05, the null hypothesis was rejected, indicating a statistically significant difference between groups. If the two groups were determined not to be statistically different, an unweighted calibration model was applied. If the two groups were determined to be statistically different, a weighted (1/x) calibration model was applied.

A plot of the residual values was then generated to confirm the model has homoscedasticity over the working range. Once the calibration model was established, it was applied to all data collected for bias and precision, lower limit of quantitation, recovery, stability, and dilution integrity. The determined model for each analyte is listed in Table 11.

Table 11: Calibration model for each analyte

Analyte	Calibration Model
Cocaine	Linear Unweighted
Heroin	Linear Weighted (1/x)
Methamphetamine	Linear Weighted (1/x)

To confirm linearity, for each calibration curve replicate the correlation coefficient was ≥0.995, and the back calculated calibrator concentrations were within ±10% of the target concentration.

4. Recovery

Recovery was assessed to gain a better understanding of the performance of the method and did not have predetermined acceptance criteria. Recovery samples were prepared daily by drying 200 µL of internal standard and reconstituting with a total of 200 µL of certified reference material (CRM) and neat solvent to produce both a 0.05 mg/mL control and a 0.1 mg/mL control. The neat solvent used was either methanol or acetonitrile based on the composition of the CRM. To allow direct comparison to the calibration curve, the concentration of the CRM was converted from free base to the HCl salt form. The reported concentrations from the five days of analysis were averaged and compared to the known concentration to determine recovery using Equation 3 for each analyte (Table 12).

Equation 3

$$Average\ Recovery_x\ (\%) = \left(\frac{Average\ Calculated\ Concentration_x}{Theoretical\ Concentration_x}\right) \times 100$$

Table 12: Average recovery for each analyte

Analyte	Theoretical Concentration (Salt Form) (mg/mL)	Average Calculated Concentration (mg/mL)	Average Recovery (%)
Cocaine	0.0560	0.0557	99.5
	0.1120	0.1112	99.3
Heroin	0.0549	0.0559	101.8
	0.1099	0.1151	104.7
Methamphetamine	0.0622	0.0707	113.7
	0.1244	0.1227	98.6

5. Interferences

Interferences were assessed by analyzing neat standards of commonly evaluated drugs and bulking agents using the instrumental method for each quantitative analyte. The retention time for each compound was noted to assist in the creation of a database for each analytical method (Table S3). An interferent was determined as being present if it was within 0.033 minutes of the quantitative analyte or its internal standard. Once an interferent was identified, the impacted compounds were reanalyzed to evaluate the impact on identification and quantitation.

Cocaine

During initial interference studies, amitriptyline was identified as an interferent with cocaine and thebaine was identified as an interferent with the dicyclohexyl phthalate (DCHP) internal standard. For reanalysis, a cocaine standard was prepared at a concentration of 0.05 mg/mL, corresponding to the lower limit of quantitation within the method. Amitriptyline and thebaine standards were prepared at a concentration of 2.0 mg/mL, corresponding to the maximum concentration within a sample following the sample preparation procedure. The DCHP internal standard was prepared at a concentration of 1.5 mg/mL, corresponding to the concentration used within the analytical method. For each interferent, the standards (both interferent and target compound) were analyzed individually as well as in a 50:50 mixture. The chromatograms were overlaid to assess the impact on identification and quantitation (Figures 1 and 2). It was determined that samples containing amitriptyline and/or thebaine would not impact identification or quantitation of cocaine.

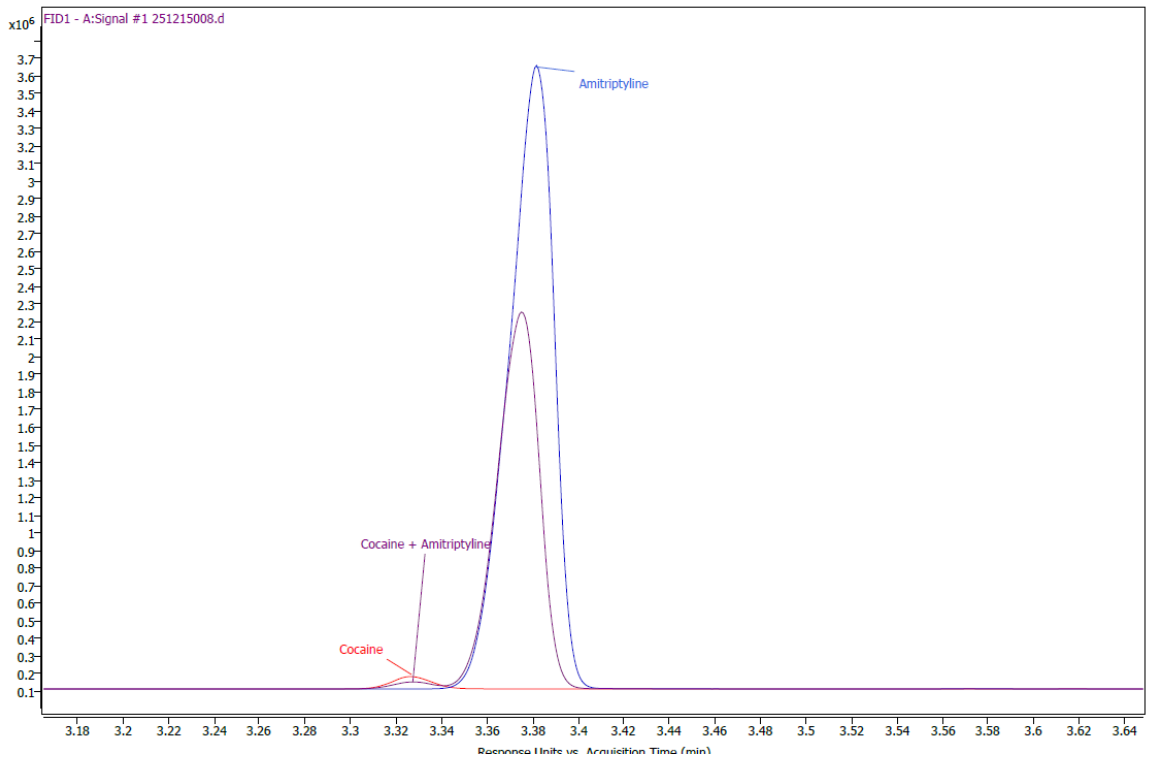

Figure 1: Overlaid chromatograms of cocaine, cocaine and amitriptyline (50:50), and amitriptyline

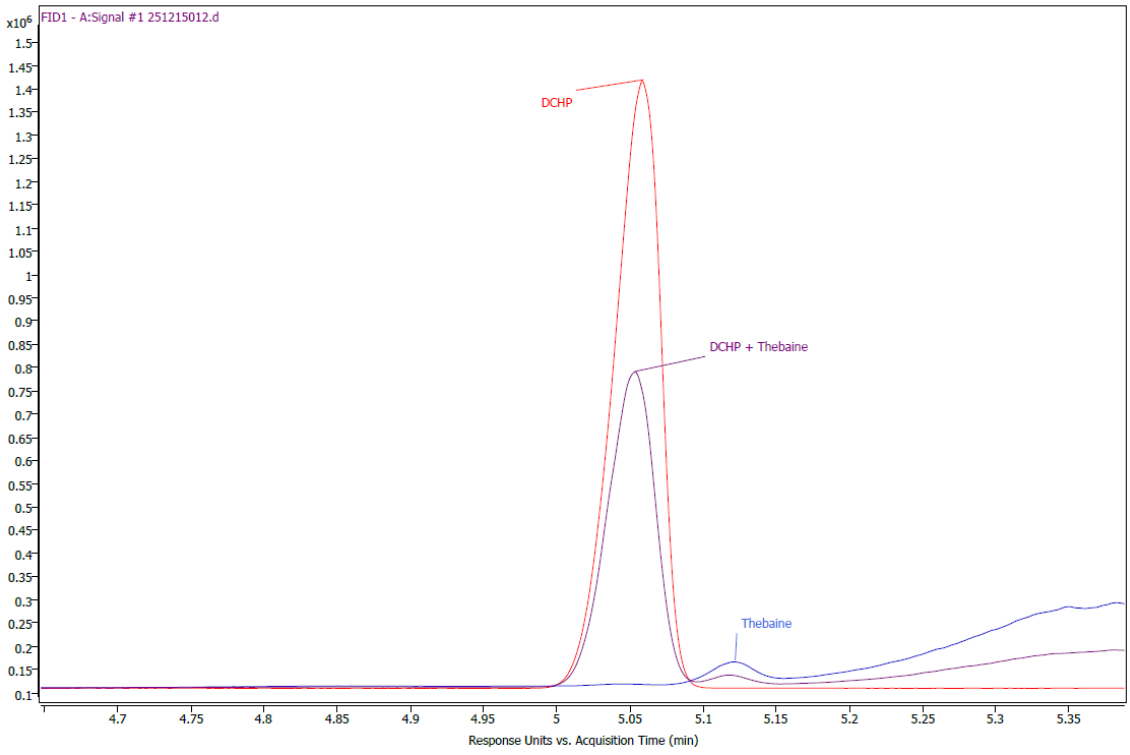

Figure 2: Overlaid chromatograms of DCHP, DCHP and thebaine (50:50), and thebaine

Heroin

During initial interference studies, hydromorphone was identified as an interferent with DCHP. For reanalysis, a hydromorphone standard was prepared at a concentration of 2.0 mg/mL, corresponding to the maximum concentration within a sample following the sample preparation procedure. The DCHP internal standard was prepared at a concentration of 1.5 mg/mL, corresponding to the concentration used in the analytical method. The standards were analyzed individually and in a 50:50 mixture. The chromatograms were overlaid to assess the impact on identification and quantitation (Figure 3). It was determined that samples containing hydromorphone would impact identification and quantitation of heroin and therefore would be unsuitable for quantitative analysis.

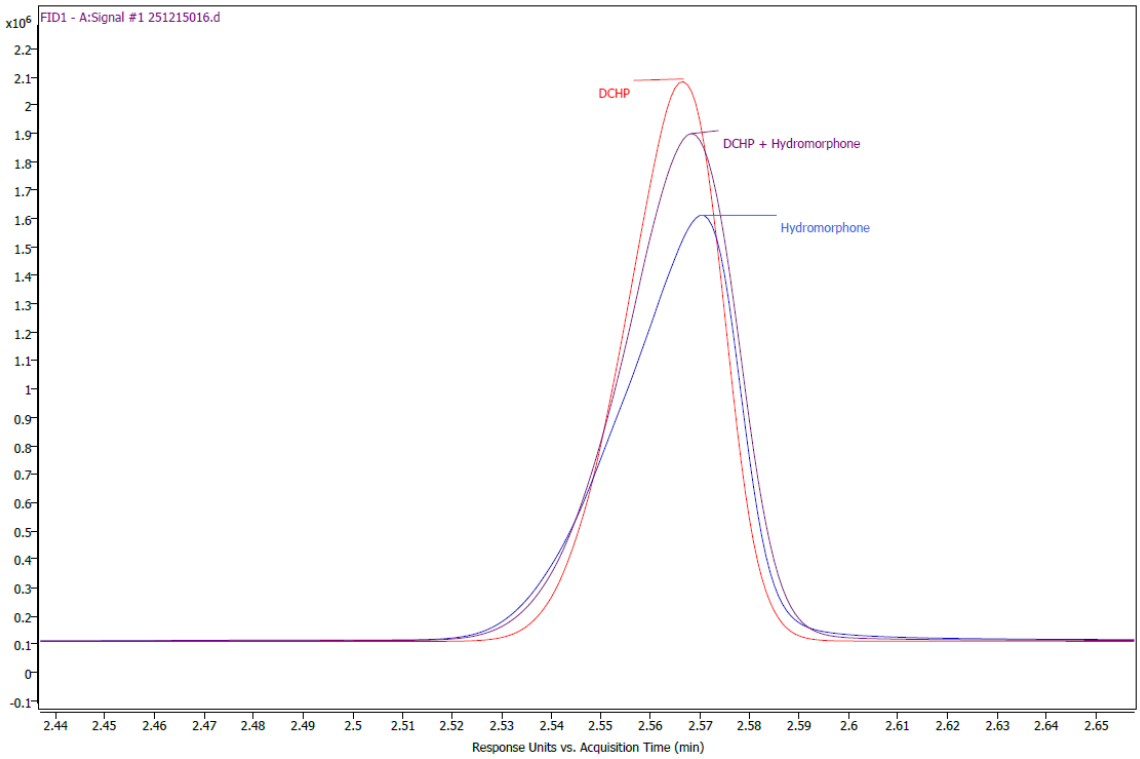

Figure 3: Overlaid chromatograms of DCHP, DCHP and hydromorphone (50:50), and hydromorphone

Methamphetamine

During initial interference studies, aspirin was identified as an interferent with methamphetamine. For reanalysis, a methamphetamine standard was prepared at a concentration of 0.05 mg/mL, corresponding to the lower limit of quantitation. The aspirin standard was prepared at a concentration of 2.0 mg/mL, corresponding to the maximum concentration within a sample following the analytical method. Standards were analyzed individually and in a 50:50 mixture. The chromatograms were overlaid to assess the impact on

identification and quantitation (Figure 4). It was determined that samples containing aspirin would impact identification and quantitation of methamphetamine and therefore would be unsuitable for quantitative analysis.

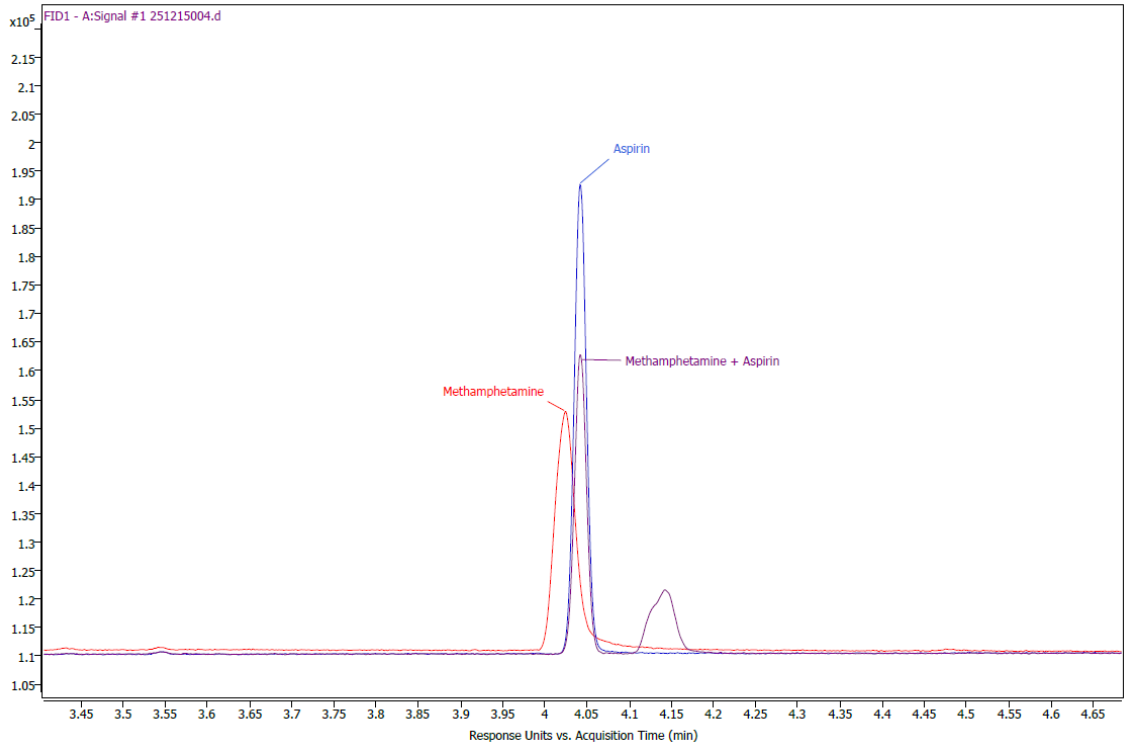

Figure 4: Overlaid chromatograms of methamphetamine, methamphetamine and aspirin (50:50), and aspirin

6. Stability

The long-term stability of calibrator and control solutions was not assessed during the validation. Therefore, calibrators and controls shall be prepared fresh for each quantitative analysis.

7. Dilution Integrity

Dilution integrity was assessed for scenarios in which the purity of the specimen is greater than the upper limit of quantitation. Dilution ratios of 1:2 and 1:5 were evaluated for bias and precision using the authentic specimens evaluated in Section 1. Six replicates were prepared undiluted, at a 1:2 dilution, and a 1:5 dilution. Since at least one of the aforementioned dilutions were outside of the calibration range, the response ratio of analyte to internal standard was utilized instead of the calculated concentration. The response ratio was adjusted depending on the dilution factor. The dilution ratio was considered acceptable if bias was ±10% of the neat sample's ratio and precision did not exceed 10%. It was determined that dilution ratios of 1:2 and 1:5 were acceptable for all three analytes (Table 13).

Table 13: Bias and precision results for each dilution ratio evaluated

Analyte	Sample	Dilution	Average [a]	Standard Deviation [a]	Bias (%)	%CV
Cocaine	TST-2	1x	0.7033	0.0517	---	7.35
		2x	0.7130	0.0544	1.39	7.63
		5x	0.7158	0.0613	1.78	8.56
	TSC-4	1x	0.8530	0.0290	---	3.40
		2x	0.8546	0.0314	0.20	3.67
		5x	0.8580	0.0387	0.59	4.51
Heroin	TSC-751	1x	0.1058	0.0033	---	3.16
		2x	0.1020	0.0027	-3.57	2.69
		5x	0.1009	0.0031	-4.62	3.11
	TSW-242	1x	0.6029	0.0123	---	2.04
		2x	0.6220	0.0111	3.17	1.79
		5x	0.6004	0.0134	-0.42	2.24
	TSC-906	1x	0.8606	0.0135	---	1.57
		2x	0.8636	0.0150	0.35	1.73
		5x	0.8373	0.0160	-2.71	1.91
Methamphetamine	TSW-471	1x	1.4282	0.0618	---	4.33
		2x	1.4308	0.0587	0.18	4.10
		5x	1.4467	0.0667	1.29	4.61
	TSC-1	1x	1.2578	0.0277	---	2.20
		2x	1.2488	0.0316	-0.71	2.53
		5x	1.2657	0.0455	0.63	3.59
	TSC-2	1x	1.0057	0.0318	---	3.16
		2x	1.0012	0.0360	-0.44	3.60
		5x	1.0176	0.0272	1.18	2.68

[a] From the response ratios of the six replicates after multiplying by the dilution factor

8. Summary

The validation demonstrated that the utilization of a multi-point calibration curve for the quantitative analysis of cocaine, heroin, and methamphetamine is fit-for-purpose. It was determined that the best fit calibration model for cocaine was linear unweighted and that the best fit calibration model for heroin and methamphetamine was linear weighted (1/x). Bias and precision predetermined acceptance criteria were met for all three analytes at all concentrations evaluated. Dilution integrity experiments indicate that samples above of the calibration range (0.05 mg/mL - 0.5 mg/mL) can be diluted using either a 1:2 or 1:5 dilution. During investigation of interferences, it was determined that samples containing hydromorphone would be unsuitable for heroin quantitation and those containing aspirin would be unsuitable for methamphetamine quantitation. Due to the evolving cutting agents utilized in illicit drug manufacturing, the continued evaluation of additional interferences is recommended.

9. References

Virginia Department of Forensic Science Quality Manual, (Qualtrax Revision 33). 2025

Virginia Department of Forensic Science Controlled Substances Procedure Manual, (Qualtrax Revision 24). 2025

Supplemental Information – Quantitative Analysis of Cocaine, Heroin, and Methamphetamine using a Multipoint Calibration Curve

Table S1: Instrumental Parameters

Parameter	Instrumental Method		
	Cocaine	**Heroin**	**Methamphetamine**
Oven Ramp	220°C for 2 min 20°C/min to 245°C 245°C for 3 min	260°C for 5 min	70°C for 0.5 min 20°C/min to 210°C
Run Time	6.25 min	5.0 min	7.5 min
Signal Collection Delay	0.80 min	0.73 min	1.00 min
Inlet Temperature	290°C		
Split	100:1		
Injection Volume	1 µL		
Column	HP-1 15m x 0.25mm x 0.25µm		
Flow	1 mL/min		
FID Temperature	280°C		

Table S2: Purity ranges of authentic materials using historical calibration curve

Analyte	**Sample Name**	**Purity ± Measurement Uncertainty (%)**
Cocaine	TST-2	75.3 ± 11.1
	TSC-4	83.1 ± 8.8
Heroin	TSW-242	61.7 ± 8.1
	TSC-284	86.0 ± 6.9
	TSC-751	11.3 ± 1.0
	TSC-906	89.9 ± 9.5
Methamphetamine	TSC-1	95.2 ± 8.4
	TSC-2	75.7 ± 8.6
	TSW-471	102.6 ± 13.6
	TSW-469	99.0 ± 12.9
	TSW-468	98.0 ± 10.5 [a]

[a] excludes one replicate due to being an outlier

Table S3: Interferences retention time database

Analyte	**Retention Time per Instrumental Method (minutes)**		
	Cocaine	**Heroin**	**Methamphetamine**
4-Piperidone	0.844	-----	3.062
Methamphetamine	0.913	-----	**4.007**
Aspirin (1)	0.914	0.812	4.042
Ethylphenidate (1)	0.923	1.052	4.319
Aspirin (2)	0.937	0.835	4.720
Thiamine	0.944	0.817	4.457
Tridecane	0.953	0.803	**4.937**
Nicotinamide	0.993	0.830	5.027
Ephedrine	1.013	0.842	5.188
Pseudoephedrine	1.014	0.836	5.197

Aspirin (3)	1.068	0.858	5.730
Dimethylterephthalate	1.110	0.871	5.919
Aspirin (4)	1.164	0.890	6.214
Benzocaine	1.187	0.897	6.277
Inositol	1.213	0.922	-----
Acetaminophen	1.307	0.940	6.810
Guaifenesin	1.314	0.942	6.753
Phenacetin	1.362	0.953	
Mannitol	1.438	0.992	7.192
NPP	1.520	1.016	7.232
Methylphenidate	1.528	1.014	7.329
Phenylfentanyl	1.532	-----	-----
Ethylphenidate (2)	1.662	-----	-----
Caffeine	1.732	1.081	-----
Antipyrine	1.890	1.144	-----
Dimenhydrinate (1)	1.930	1.123	-----
Diphenhydramine	1.930	1.122	-----
Ketamine	1.932	1.152	-----
N,N-Dimethylpentylone	1.962	1.134	-----
Lidocaine	1.986	1.146	-----
Theophylline	2.078	1.167	-----
Dexmedetomidine	2.098	1.185	-----
Aminopyrine	2.107	1.192	-----
Dipyrone (1)	2.133	1.213	-----
Phenobarbital	2.191	1.210	-----
Dimenhydrinate (2)	2.228	1.227	-----
Tramadol	2.269	1.237	-----
Xylazine	2.280	1.252	-----
Tetramisole	2.300	1.277	-----
Dipyrone (2)	2.412	1.310	-----
Procaine	2.497	1.308	-----
4-Fluoroisobutyrylfentanyl	2.727	3.699	-----
Methaqualone	3.121	1.592	-----
Dextromethorphan	3.130	1.599	-----
Methadone	3.150	1.582	-----
Cocaine	**3.337**	1.669	-----
Amitriptyline	3.372	1.698	-----
Tetracaine	3.455	1.713	-----
Cybutylone	3.617	1.807	-----
Furanyl UF17	3.742	1.882	-----
Promethazine	3.803	1.941	-----
Bis(2,2,6,6-tetramethyl-4-piperidyl) Sebacate	4.060	-----	3.691
Benzylfentanyl (1)	4.061	2.063	2.417
Codeine	4.395	2.283	-----
N-Propionyl Norfentanyl	4.629	2.348	-----
3-Acetylmorphine (1)	4.713	2.465	-----
Morphine	4.717	2.471	-----
U47700	4.734	2.431	-----
Hydrocodone	4.796	2.497	-----
Hydromorphone	4.867	2.560	-----

4-Anilino-N-phenethylpiperidine	4.909	2.515	-----
Dicyclohexyl Phthalate	**5.097**	**2.573**	-----
Thebaine (1)	5.117	2.831	-----
3-Acetylmorphine (2)	5.295	2.771	-----
Thebaine (2)	5.369	-----	-----
Acetylcodeine	5.370	2.767	-----
Thebaine (3)	5.437	-----	-----
6-Acetylmorphine	5.448	2.829	-----
Oxycodone	5.452	2.872	-----
Thebaine (4)	5.554	-----	-----
Benzoylecgonine	5.687	2.935	-----
U49900	5.959	3.092	-----
Quinidine	6.126	4.723	-----
Benzylfentanyl (2)	-----	3.261	-----
Chloroquine Diphosphate	-----	-----	-----
Heroin	-----	**3.409**	-----
β-Methyl Acetyl fentanyl	-----	3.559	-----
Acetylfentanyl	-----	3.639	-----
m-Fluorofentanyl	-----	3.657	-----
m-Fluoro Acrylfentanyl	-----	3.760	-----
p-Fluorofentanyl	-----	3.772	-----
p-Fluoroacrylfentanyl	-----	3.847	-----
o-Fluoroisobutyrylfentanyl	-----	3.856	-----
o-Fluorofentanyl	-----	3.861	-----
β-Methylfentanyl	-----	3.924	-----
o-Fluoroacrylfentanyl	-----	3.972	-----
3-Fluorofentanyl	-----	4.043	-----
Fentanyl	-----	4.060	-----
α-Methylacetylfentanyl	-----	4.065	-----
3-Methylfentanyl (trans)	-----	4.080	-----
m-Methyl Acetyl fentanyl	-----	4.093	-----
Acryl Fentanyl	-----	4.137	-----
o-Methyl Acetyl fentanyl	-----	4.174	-----
3'-Methyl Acetyl fentanyl	-----	4.320	-----
p-Fluorobutyrylfentanyl	-----	4.327	-----
p-Methyl Acetyl fentanyl	-----	4.359	-----
4'-Methyl Acetyl fentanyl	-----	4.427	-----
o-Fluorobutyrylfentanyl	-----	4.433	-----
3-Methylfentanyl (cis)	-----	4.474	-----
α-Methylfentanyl	-----	4.509	-----
2'-Methyl Acetyl fentanyl	-----	4.517	-----
o-Methylfentanyl	-----	4.589	-----
Butyryl Fentanyl	-----	4.652	-----
Quinine	-----	4.716	-----
Ocfentanil	-----	4.737	-----
p-Methylfentanyl	-----	4.784	-----
Papaverine	-----	4.872	-----
Carfentanil	-----	-----	-----
Hydroxyzine	-----	-----	-----
Valeryl Fentanyl	-----	-----	-----

Alprazolam	-----	-----	-----
2-Furanyl Fentanyl	-----	-----	-----
Noscapine	-----	-----	-----
Bromazolam	-----	-----	-----
Metonitazine	-----	-----	-----
Etizolam	-----	-----	-----
Crotonyl Fentanyl	-----	-----	-----
Cyclopropylfentanyl	-----	-----	-----
Methoxyacetylfentanyl	-----	-----	-----
β-Hydroxythiofentanyl	-----	-----	-----
Diltiazem	-----	-----	-----
4-Methoxybutyrylfentanyl	-----	-----	-----
Phenethyl 4-Anilino-N-phenethylpiperidine	-----	-----	-----
Lactose	-----	-----	-----
Polyethylene Glycol 3350	-----	-----	-----
Protonitazine	-----	-----	-----
Benzodioxolefentanyl	-----	-----	-----
Tetrahydrofuran Fentanyl	-----	-----	-----