Technical Procedure for Measurement Assurance

1.0 Purpose - This procedure specifies the required elements for measurement assurance in the Drug Chemistry Sections of the State Crime Laboratory.

2.0 Scope – This procedure applies to Drug Chemistry at the Raleigh, Triad, and Western locations of the State Crime Laboratory.

3.0 Definitions

- Measurement – a process of experimentally obtaining one or more quantity values, typically of physical, chemical, or biological nature. Implies comparison of quantities.
- Metrology – the science of measurement.
- Measurand – the (unknown) quantity subject to measurement.
- Reference standard – measurement standard designated for the calibration of other measurement standards (reference standards or equipment)
- Reference material – material sufficiently homogeneous and stable, with reference to specified properties, which has been established to be fit for its intended use in measurement or in examination of nominal properties.
- Measurement Traceability – an unbroken chain of comparisons (using acceptable and documented methods) to national or international standards (SI) with each comparison having stated uncertainties.

4.0 Equipment, Materials and Reagents

4.1 Equipment

- Section balances (individual, analytical, and bulk)
- Liquid Handling System
- Headspace GC
- Toxicology GC-MS
- HPLC

4.2 Materials and Reagents

- Class A Reference Standard Weights
- Primary Reference materials
- Volumetric flasks
- Class A Pipettes
- Glassware

5.0 Procedure

5.1 Standards and Control

5.1.1 Class A Reference Standard weights shall be used for QC checks and to determine the Uncertainty of Measurement for section balances.

5.1.2 Primary reference standards, primary reference materials, Class A pipettes and Class A volumetric flasks shall be used for Section Blood Alcohol Quantitations, Cannabinoid Quantitations, and GHB Quantitations.

5.1.3 Primary reference materials, Class A pipettes, Class A volumetric flasks and graduated cylinders shall be used for Section Methamphetamine Quantitations via HPLC.

5.2 Section Balances

5.2.1 The process to determine the Uncertainty of Measurement for Section balances shall be conducted on a yearly basis for ten consecutive business days according to the procedure outlined below.

5.2.2 In order to determine uncertainty for balances, several factors must be taken into consideration. These factors include but are not limited to:

5.2.2.1 The uncertainty of the measuring instrument (expressed as C1) shall be obtained from the statement of uncertainty from the approved vendor's current Calibration Report.

- If the expanded uncertainty was reported on the certificate provided by the vendor, divide the expanded uncertainty value by the coverage factor K.

5.2.2.2 The uncertainty of the item being measured (expressed as C2) shall be obtained from the approved vendor's current Calibration Report for the Class A Reference Standard Weights.

5.2.2.3 The uncertainty of human/environmental influences (expressed as C3) shall be obtained from the data collection performed by the Forensic Scientists in the Drug Chemistry Sections of the North Carolina State Crime Laboratory on an annual basis.

5.2.2.3.1 These factors include but are not limited to:

- Position and leveling of the balance
- Position of weight on the balance pan
- Draft
- Ambient temperature changes
- Vibration

5.2.3 All common use balances (analytical and bulk) as well as all individual top loading balances currently being used for case analysis shall be included in the data collection.

5.2.4 A rotation list of Forensic Scientists shall ensure that multiple users contribute to the data collection of common use balances.

5.2.5 If a Forensic Scientist is out of the office for a partial day or partial week during the data collection period, a substitute Forensic Scientist shall collect data on that individual's balance.

5.2.6 The monthly QC check shall be performed at the start of each work day in accordance with the Drug Chemistry Technical Procedure for Balances, but shall be documented with the replicate weight determinations.

5.2.7 In addition to the monthly QC check, each morning and afternoon three replicate weight determinations shall be obtained for two reference standard weights. The Forensic Scientist performing the determination shall record these values on a data collection sheet along with the identifier for each weight used.

5.2.7.1 The specific weights used for each type of balance will depend on certified reference weights at the respective laboratories.

5.2.8 The standard deviation of all occurrences for each weight on each balance shall be used.

5.2.9 Calculations

5.2.9.1 Data collection and data manipulation may be done in an Excel spreadsheet ("Determination of Uncertainty") due to the volume of data collected.

5.2.9.2 After completion of the data collection, the uncertainty of human/environmental influences (C3) shall be determined. The following equation shall be used to determine C3:

$$C3 = \frac{s}{\sqrt{n}}$$

Where s = standard deviation
Where n = number of measurements

5.2.9.3 Combined Uncertainties (u)

5.2.9.3.1 In order to accurately reflect the total uncertainty from all of the contributing factors, the following equation shall be used to determine the combined uncertainty (u):

$$u = \sqrt{[(C1)^2+(C2)^2+(C3)^2]}$$

Where C1 = uncertainty of measuring device
C2 = uncertainty of items being measured
C3 = uncertainty of human/environmental influences

5.2.9.4 Expanded Uncertainties at 99.7 % Confidence Level (U)

5.2.9.4.1 In order to determine the expanded uncertainty (U), the combined uncertainty (u) shall be multiplied by a coverage factor (k) of 3, which states the uncertainty at a 99.7 % level of confidence.

$$U=ku$$

Where k = a coverage factor of 3 for a 99.7 % confidence level
u = the combined uncertainty for each type of measurement

5.2.10 The expanded uncertainties for each type of measurement on each type of balance (top loading/analytical/bulk) included in the uncertainty study shall be evaluated. The highest value for each type of balance (top loading/analytical/bulk) shall be used as the section value. These values shall be updated annually and used as directed in the Drug Chemistry technical procedure for each type of measurement. See Section records for current values.

5.2.10.1 Calculations shall be verified by a second Forensic Scientist and documented on the yearly summary chart for each type of uncertainty.

5.2.11 Reporting of Final Expanded Uncertainty for the Weighing Process

5.2.11.1 The Expanded Uncertainty for each type of balance (see **5.2.10.4.1**) shall be used to calculate the Final Expanded Uncertainty for the weighing process. This process is repeated when multiple units are weighed for a combined net weight. The following equation shall be used:

$U_{final} = \sqrt{(U_{balance})^2 \times N}$ which can be simplified to

$U_{final} = \sqrt{N} \times U_{balance}$

Where:

U_{final} = Final expanded uncertainty for the weighing process
$U_{balance}$ = Expanded Uncertainty of the Balance
N = Number of weighings
99.7 % Confidence Level using k=3 coverage factor and normal distribution

5.2.11.2 The expanded uncertainty for the weighing process for the type of balance used shall be reported with the results of reported net weights. The calculations shall be recorded in the case notes.

5.2.11.2.1 Top loading (individual) balances:
Net weight of material – XX.XX (+/- 0.0X) grams
Or for upper range:
Net weight of material – XX.X (+/- 0.0X) grams

5.2.11.2.2 Analytical balances:
Net weight of material – XX.XXXX (+/- 0.000X) grams

5.2.11.2.3 Bulk balances:
Net weight of material – XX.XX (+/- 0.0X) kilograms
Or for upper range:
Net weight of material – XX.X (+/- 0.0X) kilograms

5.2.11.2.4 Gross weights shall not require a reported uncertainty and shall be truncated to the 0.1 place or whole number, depending on the range of the balance.

5.3 Blood Alcohol Concentration Determinations

5.3.1 Currently being established.

5.4 Cannabinoid Quantitations

5.4.1 Currently being established.

5.5 Methamphetamine Quantitations via HPLC

5.5.1 This method is used to determine the purity of methamphetamine as requested for certain solid drug cases undergoing federal prosecution. Quantitation of other target analytes is not within the scope of the current validated method. The method has been analyzed and tested to acquire data on the following sources of uncertainty: instrument uncertainty, uncertainty due to scientist technique, volumetric glassware uncertainty, balance uncertainty, and sample homogeneity.

5.5.2 Instrument Uncertainty

5.5.2.1 The HPLC is calibrated using an external calibration method on a five point calibration curve utilizing calibrators of methamphetamine. The correlation coefficient of the curve defined as R^2 must be better than 0.995. Policy requires that a new calibration curve be created with every run. Policy also requires that two quality controls (0.50 and 1.0 mg/mL) be analyzed with every run. The calibration is valid if both quality control samples are within +/-5% of the expected concentration.

5.5.2.2 The linearity of the technique used for methamphetamine quantitation encompasses a range of 0.05-1.0 mg/mL. Any range beyond this is not within the scope of the current validated method.

5.5.2.3 The calibration standards used to make the calibrators are purchased through an approved vendor. The calibration requirements, as well as in-house standard verification requirements, would reveal any deviations.

5.5.3 Homogeneity of the sample

5.5.3.1 This element is monitored by homogenizing all samples prior to analysis and by the use of quadruplicate measurements. The procedure for homogenizing a sample is outlined in the Technical Procedure for High Performance Liquid Chromatography. The Relative Percent Difference of the measurements must be below 3 % to ensure homogeneity. If the RPD is found to be greater than 3 %, the scientist shall prepare new sample solutions from the original homogenized powder.

5.5.4 Scientist Technique

5.5.4.1 Only scientists who have competed HPLC training shall perform HPLC quantitation to minimize the measurement uncertainty of the process. Control samples are analyzed in the same manner as the case samples with every run. The controls monitor the uncertainty contributions of the scientist, and include the uncertainty contributions from both balances and volumetric glassware.

5.5.5 Additional sources of uncertainty

5.5.5.1 Additional sources of uncertainty include lab locations, environmental conditions, and calibration standards. Each lab independently performed its own method validation. Environmental conditions did not prove to be a significant source of uncertainty and the method was validated to be performed under typical laboratory environmental conditions.

5.5.6 Overall process uncertainty

5.5.6.1 Fifty-five control samples were analyzed in the Western and Raleigh laboratories. The analysis of theses samples resulted in an average recovery of 101.11 % and a standard deviation of 1.76 %. At a 99.7 % confidence interval, z=3.0. The measurement uncertainty of the process is calculated by:

$$MU_{(\text{process meth})} = (\text{Std dev}_{(\text{process})} * (\text{z-value @99.7\%CI}))/\sqrt{4}$$
$$= (1.76 * 3.00)/\sqrt{4}$$
$$= 2.65\%$$

The overall process uncertainty of 2.65 % was rounded up to 3.0 % to provide a more conservative estimate of uncertainty.

5.5.7 Uncertainty re-evaluation

5.5.7.1 The overall process uncertainty shall be evaluated annually from control chart data and updated as needed. If the process uncertainty changes, the percentage shall be rounded up to the nearest whole number.

6.0 Limitations – N/A

7.0 Safety – N/A

8.0 References

ASCLD/LAB Level 100A Traceability presentation. Copyright 2011; Heusser Neweigh, LLC & ASCLD/LAB.

ASCLD/LAB Level 100B Measurement Assurance presentation. Copyright 2011; Heusser Neweigh, LLC & ASCLD/LAB.

ASCLD/LAB Level 100C Measurement Uncertainty Concepts presentation. Copyright 2011; Heusser Neweigh, LLC & ASCLD/LAB.

ASCLD/LAB Level 200 Measurement Confidence for the Forensic Laboratory: Measurement Uncertainty in Drug Chemistry presentation. Copyright 2011; Heusser Neweigh, LLC & ASCLD/LAB

Clark, J.P. and Shull, A.H. *Evaluation of Methods for Estimating the Uncertainty of Electronic Balance Measurements*. Westinghouse Savannah River Company, 2002.

EURACHEM/CITAC Guide CG 4: *Quantifying Uncertainty in Analytical Measurement*, Third Edition 2012.

JCGM 100:2008 Evaluation of measurement data - Guide to the Expression of Uncertainty in Measurement, First Edition September 2008.

Measurement Uncertainty for Weight Determinations in Seized Drug Analysis Supplemental Document SD-3 Revision 2. Copyright 2011; SWGDRUG.

Taylor, B.N, and Kuyatt, C.E. NIST Technical Note 1297 Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results, September 1994 Edition.

Virginia Department of Forensic Sciences. Controlled Substances Procedure Manual. Document 221-D100 Revision 7, February 6, 2012.

9.0 Records

- Determination of Uncertainty - Yearly Report for Balances
- Calibration Reports for section balances
- Calibration Reports for section Class A pipettes
- Reference Standard Weight Calibration Certificates
- Uncertainty Budget for the HPLC Quantitation of Methamphetamine
- HPLC Control charts

10.0 Attachments – N/A

Revision History		
Effective Date	Version Number	Reason
09/17/2012	1	Original Document
05/10/2013	2	**Original 5.1**- Moved first statement to apply to Section Balances only. References to traceability maps removed, since this data covered by calibration certificates **Original 5.2, 5.3** – N/A sections removed **5.2** – Section renamed and edited to cover Section Balances only **5.2.2.1** – Removed normalization calculation that is not needed **5.2.2.2** – Added reference to Class A Reference Standard Weights **5.2.2.3.1** – Section moved from below **5.2.3 – 5.2.9** – Sections moved from below; Weights used will depend on availability at laboratories **5.2.9.1** – Added name of Excel spreadsheet used to calculate data **5.2.11** – Added clarification on types of balances **5.2.11.1** – Corrected reference line number **5.3, 5.4** - Revised to "Currently being established" **5.5** – Added explanation for Methamphetamine Quantitations

		via HPLC **Original 5.7** – Removed section for GHB Quantitations **5.5.7.1 -** Added process evaluated annually **References** – Added EURACHEM/CITAC… Taylor…, and JCGM…references **Records** – Removed Measurement Assurance Cause & Effect Diagram, added Uncertainty Budget for the HPLC Quantitation of Methamphetamine and HPLC Control Charts