Cannabinoids & Impaired Driving

Building an Evidence Based Toxicology Testing Strategy

Donna Papsun, Business Scientist/Tox Liaison
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What We Want You to Take Away Today

1. Cannabis impairment is complex.

There is no single THC concentration that establishes impairment; toxicology is one component of the totality of the investigation.

2. The quality of the testing matters.

DUI/DUID testing should be performed using validated, confirmatory methods within an accredited forensic laboratory so results are scientifically defensible and court-ready.

3. North Carolina can use an operational model that fits existing processes.

Agencies can continue their current blood-collection process while NMS supports testing, NC-specific review, required report distribution, discovery, and testimony.

4. There is flexibility in how North Carolina could implement testing.

NMS can support individual LEAs today, regional/DA-coordinated programs, or a future statewide model.

Challenges in Impaired Driving are multifactorial

Toxicology testing is widely variable, for numerous reasons

Graphic courtesy of Grace Cieri, Mandi Mohr & Melissa Fogarty at the CFSRE

Changing Landscape of Cannabis & Impaired Driving

Policy shift from prohibition to legalization

- Medical use
- Adult-use/recreational use

Growing prevalence of cannabis exposure

- Greater availability
- Commercial product evolution led to more diverse compounds (i.e. Delta-8)
- Routinely encountered in all medicolegal investigations; significance varies

Impairment is different from presence

- No universally accepted cannabinoid concentration that established impairment
- Need to understand nuances of toxicology testing

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Cannabis Use & Policy in the US

Increasing complex landscape over time

- **Legalized medical cannabis**
- **Decriminalized possession of cannabis**
- **Legalized recreational cannabis**

? Acute vs Chronic Use

? Different formulations

? Increasing product potency

? Route of administration

? Passive exposure

?Time of last use?

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Article

OXFORD

Four-year evaluation of drug-impaired driving drug concentrations

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Table 10. Cannabinoid percent positivity, count, average concentration, median concentration, min and max concentration by year.

Drug	Year	Positivity (%)	Count (n)	Average (ng/mL)	Median (ng/mL)	Min (ng/mL)	Max (ng/mL)
11-Hydroxy Delta 9 THC	2017	28	5018	3.8	2.8	1.0	53
	2018	30 α	5392	3.9	2.9	1.0	49
	2019	32 α, β	6101	4.0 α	2.9	1.0	170
	2020	32 α, β	5444	3.9	2.9	1.0	50
Delta-9 Carboxy THC	2017	45	7951	50	33	5.0	990
	2018	46	8048	51	34	5.0	860
	2019	46	8880	55 α, β	36	5.0	1700
	2020	49 α, β	8253	57 α, β	39	5.0	800
Delta-9 THC	2017	44	7710	6.4	4	0.5	140
	2018	45 α	8023	6.8 α	4.4	0.5	100
	2019	47 α, β	8970	7.1 α, β	4.5	0.5	230
	2020	49 α, β	8110	7.3 α, β	4.5	0.5	160

α – statistically different than 2017 at alpha level of 0.05.
β – significantly different than 2018 at alpha level of 0.05.

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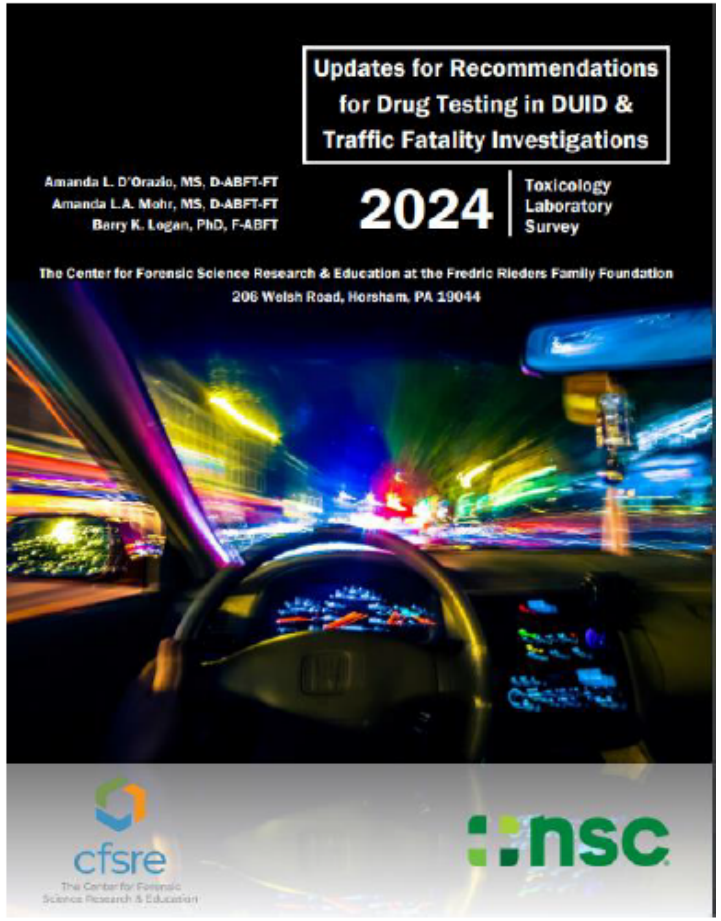
Most Prevalent Drugs Reported

Prevalence	Compound/Class
1 (More)	THC and metabolites
2	Amphetamine/Methamphetamine
3	Fentanyl
4	Cocaine and metabolites
5	Alprazolam/alpha-hydroxyalprazolam
6	Clonazepam/7-aminoclonazepam
7	Diphenhydramine
8	Oxycodone
9	Diazepam/nordiazepam
11	Lorazepam
12	Methadone and metabolite
13	Novel benzodiazepines
14	Zolpidem
15 (Less)	Tramadol/O-Desmethyltramadol



https://www.cfsre.org/images/Presentations/2024_Survey_Report.pdf

Courtesy of Amanda D'Orazio, MSFS, D-ABFT-FT

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Effects of Cannabis

THC is different and more difficult to correlate with impairment compared to EtOH

Physiological

- Tachycardia
- Increased blood pressure
- Increased body temperature
- Reddened conjunctiva
- Increased appetite
- Vasodilation
- Bronchodilation
- Decreased respiratory rate

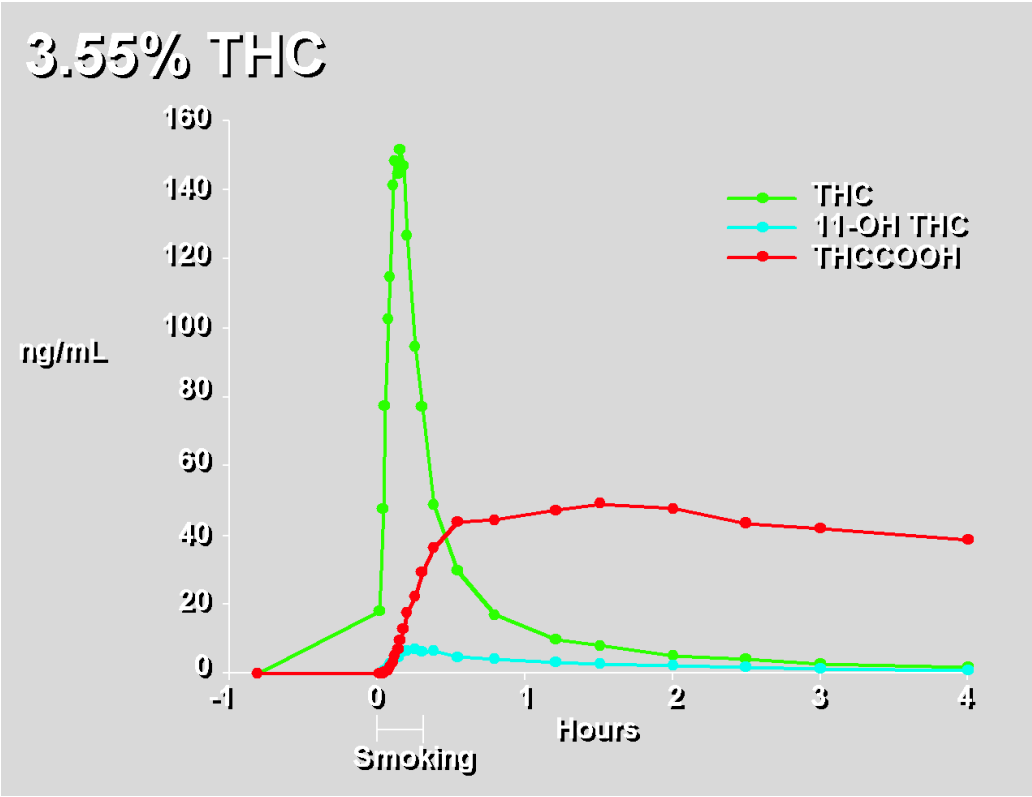
Cognitive & Psychomotor

- Relaxation
- Feelings of well-being
- Dizziness
- Fatigue, sleepiness, lethargy
- Short-term memory deficits
- Impaired space and time perception
- Decreased motor coordination
- Slowed reaction time

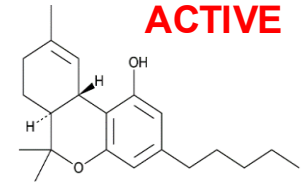
Blood Pharmacokinetics

Timing & concentrations influences by route of administration, history of use, and other variables

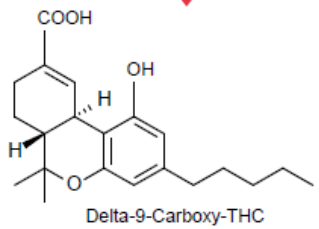
Inhalation



Oral

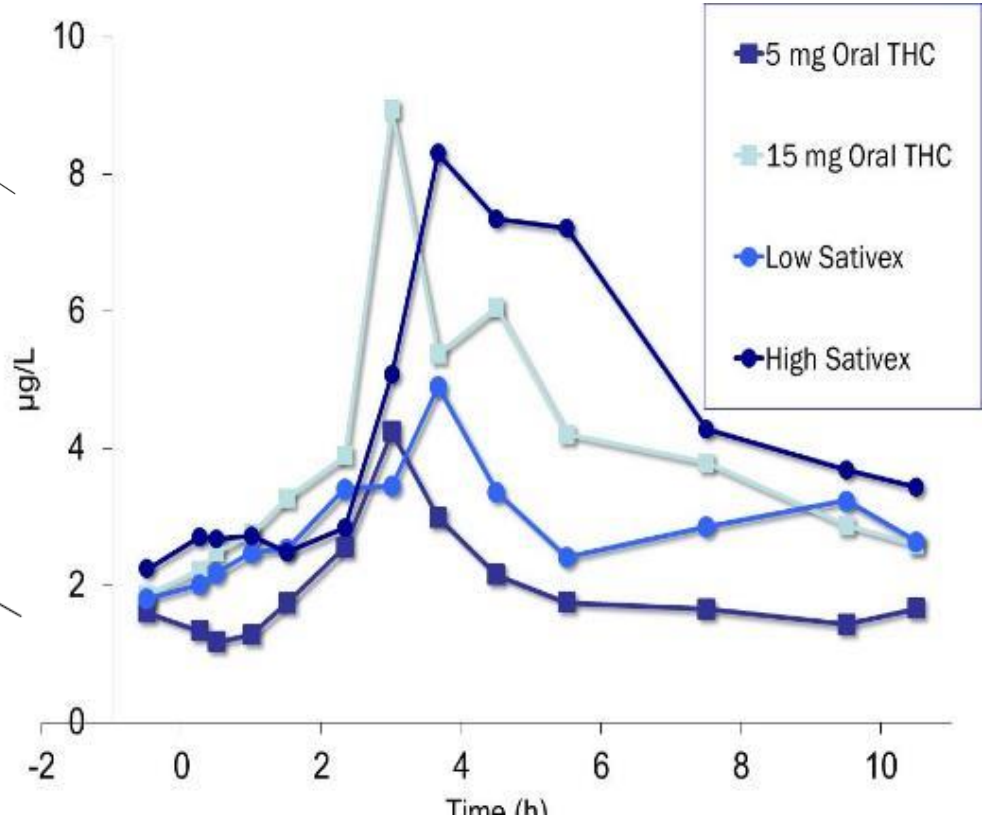


Delta-9-THC



Delta-9-Carboxy-THC

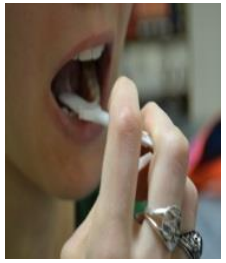
NON-ACTIVE



Huestis et al. (1992) Blood Cannabinoids. I. Absorption of THC and Formation of 11-OH-THC and THCCOOH during and after smoking of marijuana. *Journal of Analytical Toxicology.*

Obtaining Biological Samples

All states widely recognize blood and urine testing as standard analytical approaches in DUID investigations. Oral fluid is gaining acceptance.



	Urine	Blood	Oral Fluid
Invasive	√√	√√√	√
Related to Recent Use	√	√√√	√√√
Correlated to Degree of effect	-	√√	√
On-Site Testing Capability	√	-	√√√
Can be collected at roadside	-	-	√√√
Volume available for testing	~50mL	~10mL	~1mL
Cost for sample collection	$$	$$$$	$
Cost for confirmatory testing	$$	$$	$$
Interpretable?	Qual	Quant	Qual

Slide courtesy of Mandi Mohr, CFSRE

Widespread Adoption in the US

Current Barriers

- Lack of information for users about device performance in a law enforcement setting
- Risks of selecting a sub-optimal device and lack of information about costs of switching
- Unavailability of validated lab-based oral fluid tests
- Concerns regarding investigations and less complete documentation of observations
- Not all states have approved statutes that allow OF as a collectible specimens

Slide courtesy of Mandi Mohr, MS, D-ABFT-FT, Center for Forensic Science Research & Education

Laboratory Testing

Analysis of biological specimens for forensic toxicology use should be conducted by an accredited lab
– *requires resources!*

Ensure the lab has Standard Operating Procedures

Methods should be validated according to industry standards

Instrument maintenance logs

Quality control and assurance practices

Data support packages available on request

Very important for defensibility of results in the courtroom

Method development and validation is resource intensive, requiring a lot of different expertise, instruments, consumables, infrastructure, etc. Requirements for assays are also increasingly over time.

Specimen Processing: Log-in

Sample Submission & Receipt

Samples are sent to NMS Labs by submitting agencies

- Typically sent through the mail
- Occasionally hand-delivered

Each case is opened and contents are verified with associated paperwork

Case is logged into NMS Labs Laboratory Information Management System (LIMS) and assigned a unique 8-digit identifier

- First two numbers start with last digits of submitting year (ex. 2021 -> 21XXXXXXXX)
- Cases are also barcoded with unique identifier

Forensic Requisition Form

Form to be completed by submitting agency

Overall Process

Information taken from requisition used to log the case into the NMS system; some of the information will also appear on the final Toxicology Report

Submitting agency labels may be affixed to the NMS requisition, but information may not appear on report (depending on the identifiers)

Sample sealed or not

Sample seal label information

Sample label: label as information on tube (matches/compares to paperwork)

Sample seal dated

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ANALYSIS REQUISITION AND CHAIN OF CUSTODY

200 Welsh Road, Horsham, PA 19044-2208,
(215) 657-4900 · (866) 522-2216 · Fax: (215) 368-1501
www.nmslabs.com

NMS USE ONLY
DO NOT WRITE IN THIS SPACE

Client Profile (Account #): 00000 **Client Name:** National Medical Services

Work ID (Subject ID or Case No.): 0124JS

Sample ID (Subject or Case Name): Smith (Last Name), Jane (First Name)

Date of Birth (mm/dd/yyyy): _____ **Sex:** ☐ Male ☑ Female

Collection Date (mm/dd/yyyy)	Collection Time (military)	Specimen Type (e.g. blood, urine)	Specimen Source (e.g. cardiac, vitreous)	Container Labeled as (client identifier)
01/22/2024	1931	Blood	Heart	

If sending more than 5 samples, please include the same detail for each sample.

☐ **RETURN SPECIMEN** (add'l charge) ☐ Do not micro specimen ☐ Do not consume specimen

Additional information (e.g. pathologist, officer, county, etc.):

Name(s) _____

Phone # _____ Email _____

Tests Requested: Please place a check mark next to requested test(s).

Other Testing:
(The test code and name must be entered. Requisitions submitted without a test code will cause a delay and/or may not be ordered at time of receipt. If you need assistance, contact our Client Support department at 866.522.2216)

Test Code _____ Test Name _____ Test Code _____ Test Name _____

DO NOT ADD TESTING HERE:

☐ Vehicular ☐ Homicide ☐ Suicide ☐ Suspected OD ☐ Accidental Death ☐ Natural Causes ☐ Undetermined

Brief Case History / Circumstances of Death: _____

DATE	RELINQUISHED BY	RECEIVED BY	PURPOSE OF TRANSFER

For a complete list of test offerings, visit www.nmslabs.com. If you need assistance, contact us at 866.522.2216

PM-Req (NMS v.3) Generated (20220418)

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Specimen Processing: Accessioning/Aliquoting

Forensic Testing

Testing is added per client request; testing workflow is dictated by test requested

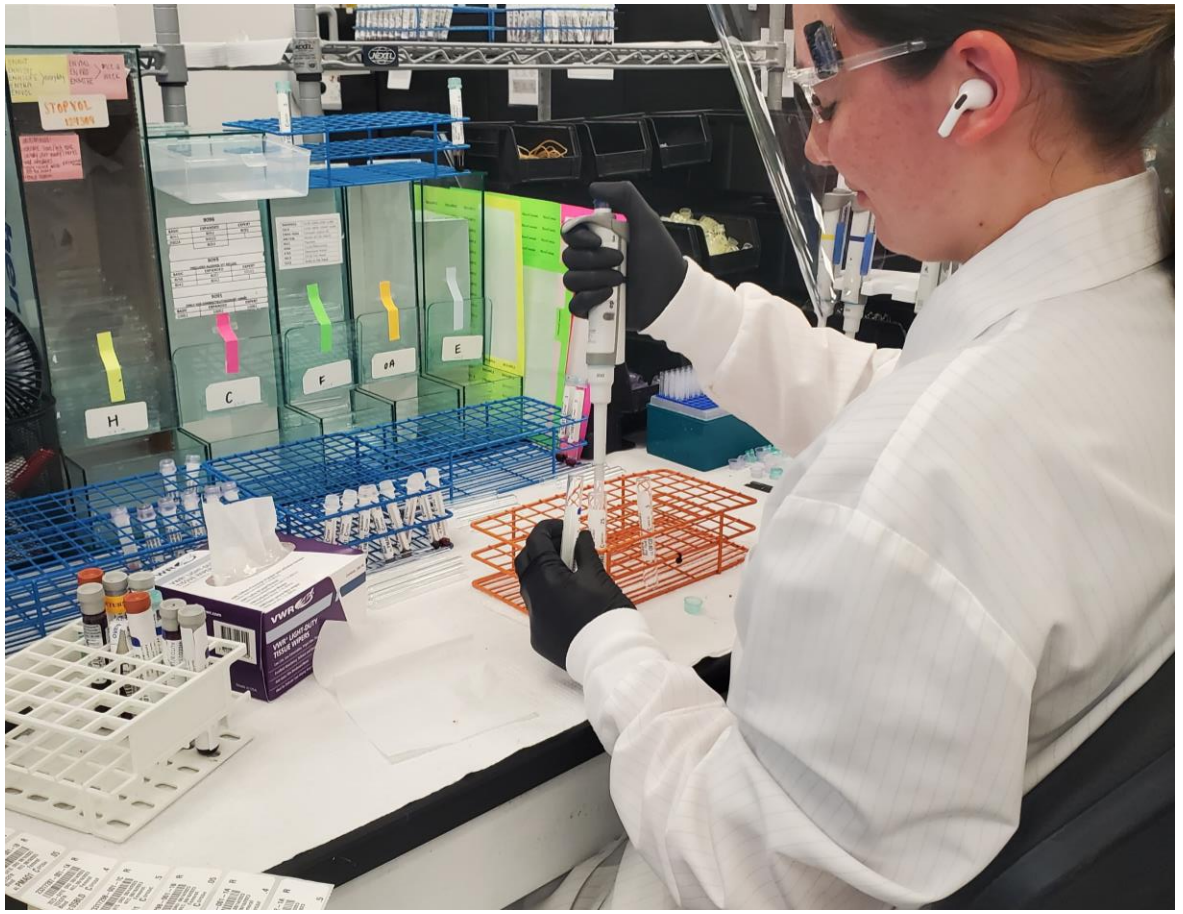
In forensic testing, parent containers are maintained in specimen processing

Aliquots are generated from parent container

The “aliquoter” removes a set amount of sample from the parent container and transfers into a clean and bar-coded tube

Aliquots are transferred to testing departments

Both parent containers and aliquots are tracked for chain of custody by scanning their barcodes



Sample History Report – Chain of Custody document

Physical handling of sample

Container [redacted]-001-1		Parent Container		
Date	**From**	**To**	**Received By**	**Reason**
07/20/2023	Secured Storage (SP)	Login COR-Forensic Spec Proc	Person A	LOGIN
07/21/2023	Login COR-Forensic Spec Proc	COR SP Aliquot Area	Person B	Aliquot
07/21/2023	COR SP Aliquot Area	COR UL 10 Refrigerator	Person B	Transfer to Storage
07/21/2023	COR UL 10 Refrigerator	COR SP 60 WalkIn Refrigerator	Person C	Transfer to storage
07/26/2023	COR SP 60 WalkIn Refrigerator	COR SP Sorting Area	Person D	Aliquot
07/26/2023	COR SP Sorting Area	COR SP Aliquot Area	Person E	Aliquot
07/26/2023	COR SP Aliquot Area	COR UL 10 Refrigerator	Person E	Transfer to Storage

Container [redacted]-001-1A		Aliquot Container		
Associated Procedure(s)	Tecan Prep Tecan Analytical			
Date	**From**	**To**	**Received By**	**Reason**
07/21/2023	Created	[redacted]	Person B	Aliquot
07/21/2023	COR SP Aliquot Area	COR UL 18 Refrigerator	[redacted]	Transfer to Department
07/25/2023	COR UL 18 Refrigerator	COR UL Prep Area		Prep
07/25/2023	COR UL Prep Area	COR SC Tecan		Analysis

Container [redacted]-001-1D		Aliquot Container		
Associated Procedure(s)	Cocaine and Metabolites Prep			
Date	**From**	**To**	**Received By**	**Reason**
[redacted]	[redacted]	COR SP Aliquot Area	Person E	Aliquot
07/26/2023	COR SP Aliquot Area	COR UL 101 Refrigerator	[redacted]	Transfer to Department
07/28/2023	COR UL 101 Refrigerator	COR Batch Assembly Station		Batch Assembly
07/28/2023	COR Batch Assembly Station	COR PM 16 Refrigerator		Transfer to Storage
07/29/2023	COR PM 16 Refrigerator	COR UL Prep Area		Prep
07/29/2023	COR UL Prep Area	Final Disposition		Disposal

Container [redacted]-001-1D1		Instrument Vial		
Associated Procedure(s)	Cocaine and Metabolites Analytical			
Date	**From**	**To**	**Received By**	**Reason**
07/28/2023	Created	COR Batch Assembly Station	[redacted]	Aliquot
07/29/2023	COR Batch Assembly Station	COR LCMS Instrument		Analysis

Sample Preparation

Steps

Scientist assembles an analytical batch consisting of case samples, calibrators, and quality controls

Performs extraction step per Standard Operating Procedure (SOP)

- Series of chemical steps in order to isolate analytes of interest from biological matrix

For many analyses, extracts are transferred to labeled vials → vials are placed on the instrument

Instrument Analysis

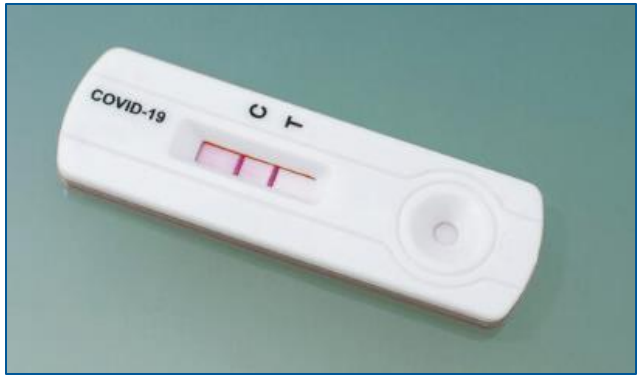
Laboratory Testing

Presumptive Tests – give a general indication of classes of substances that *may* be present

Quicker, higher chances for false positives and false negatives

Are generally not admissible in court by themselves

Newer technology may presumptively detect individual substances vs subclass



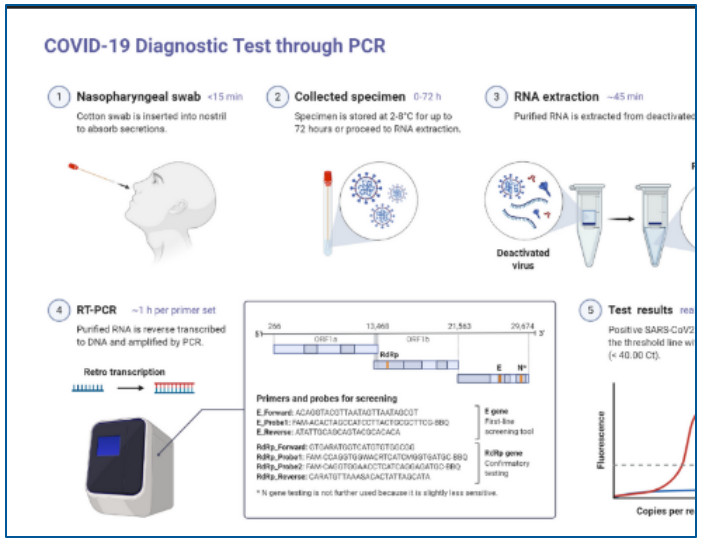
Confirmatory Tests – definitively identify analytes present in the given matrix

Provide structural information about a substance based on mass spectrometry

Should be combined with chromatography for separation

Often quantitative (how much of a substance present in matrix)

Much more sensitive and specific, takes longer



Forensic Burden of Proof: Combination Screen & Confirm

Screening - Basic

Immunoassay technique – detected absence or presence of drug

Plates Targeted Towards Subclasses

1 Strip method names

2 Sample ID 1

3 Difference data

4 b\b0

5 Cutoff results

	1	2	3	4	5
A1	4	STDBLK-17216225	2.264	100	ND
B1	4	CUTOFF-17216226	1.075	47.482	DETECTED
C1	4	QCNEG-17216227	1.505	66.475	ND
D1	4	QCPOS-17216228	0.693	30.61	DETECTED
E1	4	26357627-001-1B	0.073	3.2244	DETECTED
F1	4	26341846-001-1C	2.274	100.44	ND
G1	4	26353495-001-1B	2.501	110.47	ND
H1	4	26351014-001-1B	0.088	3.8869	DETECTED
A2	4	26351049-001-1B	0.075	3.3127	DETECTED
B2	4	26305106-001-1B	2.383	105.26	ND
C2	4	26357653-001-1B	0.057	2.5177	DETECTED
D2	4	26357677-001-1B	2.425	107.11	ND

4 = THC

Magellan V 7.2

Confirmation Tests

Forensic Toxicology Reporting

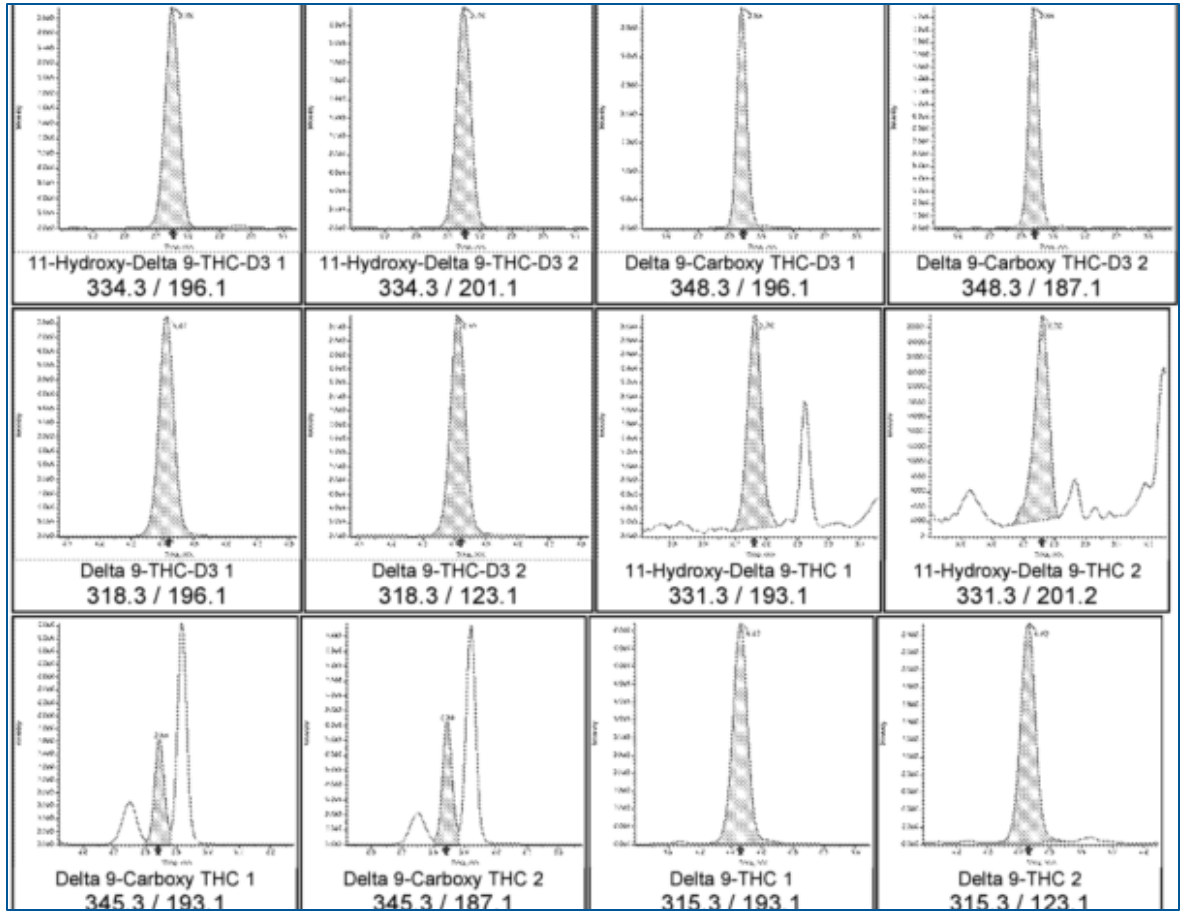
Combination of screen and confirmation tests intended to meet forensic burden of proof

Confirmation methods are often chromatographic techniques coupled with mass spectrometry

Combination of unique characteristics of analyte for identification

Confirmation results are often quantitative after use of calibration curve

Testing with different technique reduces risk of error (e.g sample switch, contamination)

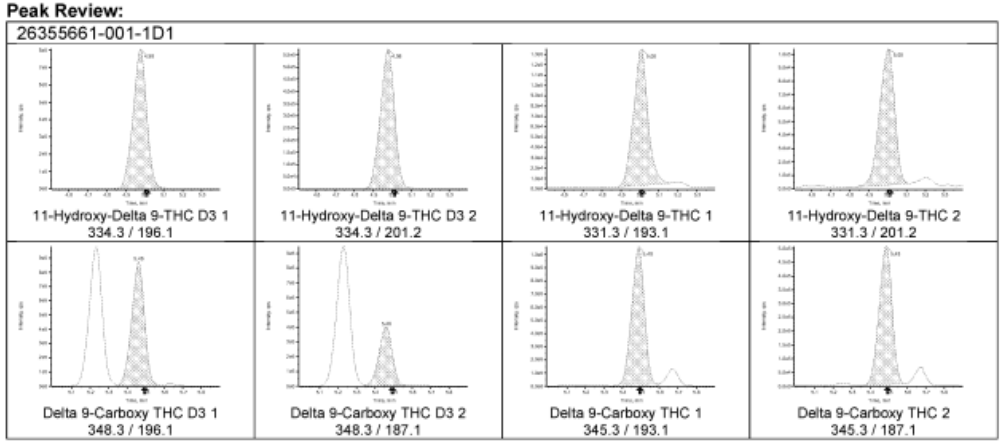


Reporting

Internal Standard	Area	RT	Target Conc.	ISTD % Recovery	ISTD Recovery Evaluation	Ion Ratio	Ion Ratio Pass?
11-Hydroxy-Delta 9-THC D3 1	4018583	4.98	1.00	101.5	Pass	0.730	Pass
11-Hydroxy-Delta 9-THC D3 2	2934629	4.98					
Delta 9-Carboxy THC D3 1	4136115	5.46	1.00	110.2	Pass	0.471	Pass
Delta 9-Carboxy THC D3 2	1946316	5.46					
Delta 8-Carboxy THC D3 1	4725601	5.23	1.00	103.3	Pass	0.969	Pass
Delta 8-Carboxy THC D3 2	4580055	5.23					
Delta 9-THC-D3 1	4618950	8.07	1.00	67.7	Pass	0.472	Pass
Delta 9-THC D3 2	2178466	8.07					
Delta 8-THC-D3 1	6073030	8.38	1.00	89.2	Pass	0.508	Pass
Delta 8-THC D3 2	3085527	8.38					

26355661-001-1D1 Target Analyte	Area	Response	RT	RRT	Ion Ratio	Ratio Pass?	Target conc.	Calc. Conc.
11-Hydroxy-Delta 9-THC 1	691812	0.172	5.00	1.006	0.803	Pass	N/A	**3.332** ng/mL
11-Hydroxy-Delta 9-THC 2	555570		5.00	1.005				
Delta 9-Carboxy THC 1	5102370	1.234	5.48	1.005	0.475	Pass	N/A	**24.803** ng/mL
Delta 9-Carboxy THC 2	2423311		5.48	1.005				
Delta 8-Carboxy THC 1	40412	0.009	5.25	1.005	1.181	Pass	N/A	**0.012** ng/mL
Delta 8-Carboxy THC 2	47733		5.25	1.004				
Delta 9-THC 1	1521817	0.329	8.10	1.003	0.469	Pass	N/A	**3.221** ng/mL
Delta 9-THC 2	714240		8.10	1.003				
Delta 8-THC 1	N/A	N/A	N/A	N/A	N/A	**Fail**	N/A	**N/A** ng/mL
Delta 8-THC 2	N/A		N/A	N/A				

Peak Review:



Positive Findings:

Analyte	Result	Units	Matrix Source
11-Hydroxy Delta-9 THC	3.3 ±1.0	ng/mL	001 - Blood
Delta-9 Carboxy THC	24 ±7	ng/mL	001 - Blood
Delta-9 THC	3.2 ±1.0	ng/mL	001 - Blood

Quantitative results are reported as Result +/- Uncertainty of Measurement (UM). Ethanol results are reported at a coverage probability of 99.73%; all other analytes are reported at a coverage probability of 95.45%.

See Detailed Findings section for additional information

Detailed Findings:

Analysis and Comments	Result	Units	Rpt. Limit	Specimen Source	Analysis By
Ethanol	None Detected	mg/dL	10	001 - Blood	Headspace GC
Ethanol	None Detected	mg/dL	10	001 - Blood	Headspace GC
11-Hydroxy Delta-9 THC	3.3	ng/mL	1.0	001 - Blood	LC-MS/MS
Delta-9 Carboxy THC	24	ng/mL	5.0	001 - Blood	LC-MS/MS
Delta-9 THC	3.2	ng/mL	0.50	001 - Blood	LC-MS/MS

Examination of the specimen(s) submitted did not reveal any reportable findings by procedure(s) outlined in the accompanying Analysis Summary, other than those listed above. Interpretation of reported findings should be based on the totality of available case information. Reference information is not case-specific but is provided as a general guide.

Reference Comments:

1. 11-Hydroxy Delta-9 THC (Active Metabolite) - Blood:

   11-Hydroxy delta-9 THC is an active metabolite of delta-9 THC, which is the principal psychoactive component of cannabis and the active component of some prescription medications. Peak blood 11-hydroxy delta-9 THC concentrations of <1-30 ng/mL occur between approximately 5 min and 3.5 hr after use. Peak concentrations, time to peak, time of detection, and half-life vary depending on dose, frequency of cannabis use, and route of administration. Concentrations generally decrease to <1 ng/mL within 24 hr.

   11-Hydroxy delta-9 THC effects may include relaxation, euphoria, and feelings of well-being. Adverse effects may include distorted perception, impaired coordination, difficulty in thinking and problem-solving, problems with learning and memory, confusion, dizziness, somnolence, ataxia, speech difficulties, lethargy, and muscular weakness. Effects of 11-hydroxy delta-9 THC on driving ability may include weaving, inattention, poor coordination, and slowed reaction time with increased error rates in complex tasks.

Testimony

The NMS toxicologist electronically signs the case once they perform an independent review of the case

- The NMS toxicologist does not physically handle the samples under the routine course of business

The NMS toxicologist, as the author of the report, often testifies to both the laboratory procedures and interpretation of the toxicology results

The testimony of the NMS toxicologist has frequently satisfied confrontation concerns, as opposed to requesting all individuals involved in the COCs to appear in court

- Jurisdiction specific
- Recent *Smith v Arizona* SCOTUS ruling has introduced some complexities

Supportive case law:

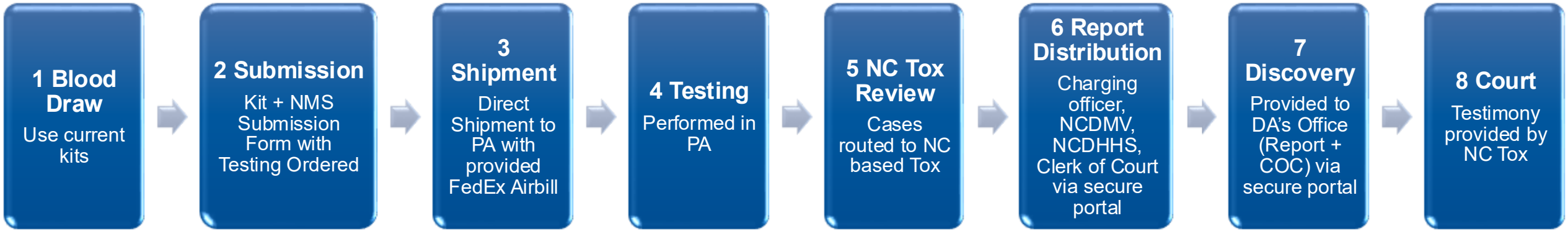
- Commonwealth of Pennsylvania vs Yohe

Totality of Investigation

Integration of

- Driving behavior and crash circumstances
- Law-enforcement observations
- Standardized field sobriety testing (SFSTs) and other behavioral indicators
- Drug Recognition Expert (DRE) evaluation, when available
- Toxicology Report
- Statements regarding cannabis use
- Timing, route, and amount of cannabis consumed

North Carolina Operational Workflow



- **Blood Draw:** Agencies continue using their existing blood-collection process and kits.
- **NC statutory reporting requirement:** Under G.S. 20-139.1(c1), a copy of a blood or urine chemical-analysis report must be provided to the charging officer, Clerk of Superior Court, NCDMV and NCDHHS.
- **Court Testimony:** When an NC-based toxicologist testifies, the hourly and daily expert testimony rate is $0, subject to the NC LEA agreement and annual testimony-volume provisions. Non-local toxicologist testimony is avoided whenever possible.

North Carolina – Partnership Models

1. Individual LEA Model — Available Now

Agencies submit directly under their own NMS account.

- Statewide discounted NC LEA pricing
- Billing tied to the submitting agency
- Best for agencies with independent funding

2. Regional / DA-Coordinated Model — Available Now

A District Attorney's Office or County coordinates submissions for participating LEAs.

- Useful when funding is managed by a DA's Office or County

3. Statewide Program Model — Future Option

A scalable model if North Carolina identifies statewide funding.

- Volume-based pricing/testimony terms
- Supports individual agencies, districts, or statewide allocation
- Can begin as a pilot and expand as volume becomes clear

Contact Information

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NMS LABS


Questions?
Answers.