Risk-Limiting Audit Report

March 31st, 2021

Executive Summary

On Tuesday March 2nd, Virginia Department of Elections (ELECT) announced the resounding success of their first statewide Risk-Limiting Audit (RLA). The audit confirmed the results of the 2020 Presidential Election and US Senate race with over 99% confidence. The following memo provides a detailed overview of a.) Risk-Limiting Audits, b.) Risk-Limiting Audits in Virginia, c.) Design and Implementation of the first statewide Risk-Limiting Audit in Virginia, d.) Results and Conclusions of the first statewide Risk-Limiting Audit in Virginia.

Brief Introduction of RLA

A RLA is a type of post-election audit that utilizes statistical methods and a manual review of paper ballots to check that the voting equipment accurately reported the correct outcome of an election. RLAs provide strong statistical evidence that the declared winner of a contest actually received the most votes.

RLAs provide a more cost effective and efficient alternative to other forms of post-election audits by reducing the number of paper ballots needed to confirm election results. In order to conduct a RLA, a voting system must be in place that produces paper ballots. RLAs analyze a random sample of hand-counted ballots to confirm election results. If the margin of an election is wide, less ballots are audited; if the margin is narrow, more ballots will be audited until enough evidence can confirm the results of the contest.[1] The margin of an election also determines the *risk-limit* of the audit. A *risk-limit* is the maximum chance that the audit will fail to correct an incorrectly reported outcome. For example, a 10% risk-limit means that there is as a 90% chance that the audit will correct an incorrect outcome.

There are two main types of risk-limiting audits: *ballot-comparison* and *ballot-polling audits*. *Ballot-comparison* audits manually examine randomly selected paper ballots and the results to the voting system's interpretation of the same ballot. *Ballot-polling audits* manually review a random sample of ballots to determine if the overall outcome of an election was correctly reported. Ballot polling requires more ballots to be audited, although it is simpler to complete; while ballot comparisons audit fewer ballots and require more data. Calculations for both ballot-polling and ballot-comparison audits are meant to be simple and can be independently verified by the public, allowing for more transparency in the auditing process.[2]

While RLAs may be conducted without software, technology is necessary when conducting a RLA on a statewide level to help manage the data. Software programs can assist with collecting

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[1] Risk-Limiting Audits, Postelection Audits, A Summary, https://www.ncsl.org/research/elections-and-campaigns/risk-limiting-audits.aspx

[2] A Gentle Introduction to Risk-Limiting Audits, Mark Lindeman and Phillip B. Stark, IEEE Security and Privacy, Special Issue on Electronic Voting, 012, https://www.stat.berkeley.edu/~stark/Preprints/gentle12.pdf

local ballot manifest, estimating the sample size, selecting ballots for audit, recording discrepancies in audited ballots, as well as determining the scope of the audit.[3]

Risk Limiting Audits in Virginia

Throughout the United States, risk-limiting audits are attracting attention and gaining in popularity with election administrators. Virginia is one of four states, including Colorado, Rhode Island, and Nevada, who have adopted a statutory requirement to coordinate risk-limiting audits annually, while several states, like Michigan, Georgia, New Jersey and Indiana, have administered pilot programs.[4]

In 2017, the Virginia General Assembly passed legislation that amended the Code of Virginia to include risk-limiting audits of ballot scanner machines in use in the Commonwealth (*to reference the full text please see appendix*.)[5] Pursuant to § 24.2-671.1., the changes went into effect on July 1st, 2018 and stipulated that:

- The localities shall be chosen at random with every locality participating in the Department's annual audit at least once during a five-year period.
- The audit will have no impact on the election results.
- No audit will be conducted until after an election has been certified and the period to initiate a recount has expired.
- Audits will be conducted by the local electoral boards and general registrars in accordance with guidelines established by ELECT.
- Candidates and political parties may have representation observe the audits.[6]

Over the past two years, Virginia has held ten risk-limiting audit pilots in thirty-five localities in the Commonwealth.

Statewide Audit: Design and Logistics

On January 12th, 2021, ELECT announced that the first statewide post-election risk-limiting audit would take place in February. The RLA would examine both the 2020 Presidential Election as well as the US Senate Race. The following is an illustrated example of the timeline of the audit:

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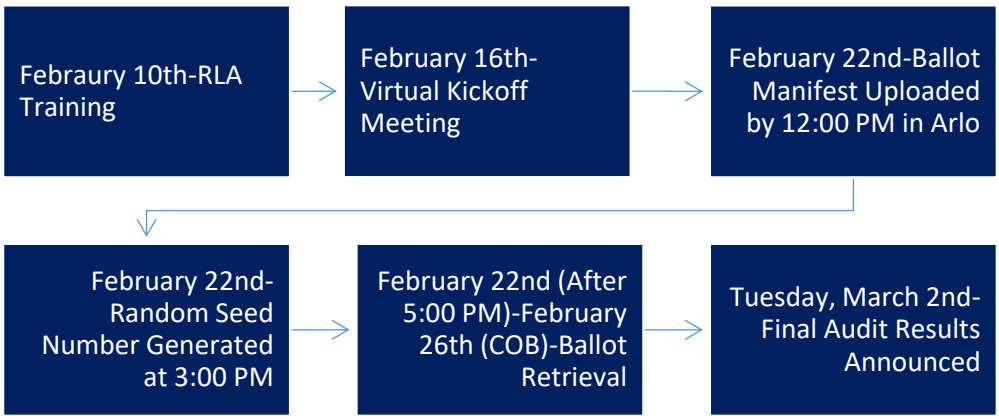
[3] National Conference of State Legislatures, Risk-Limiting Audits, https://www.ncsl.org/research/elections-and-campaigns/risk-limiting-audits.aspx

[4] National Conference of State Legislatures, Risk-Limiting Audits, https://www.ncsl.org/research/elections-and-campaigns/risk-limiting-audits.aspx

[5] Code of Virginia, 24.2-671.1 Audits of ballot scanner machines, https://law.lis.virginia.gov/vacode/title24.2/chapter6/section24.2-671.1/

[6] Code of Virginia



ELECT partnered with VotingWorks, a non-profit organization that hosts an open-source audit software called Arlo, to assist with the technical side of the audit process. Due to high margins in both the Presidential (10.11%) and US Senate Race (12.08%), fewer ballots were needed to conduct the audit. Arlo uses the BRAVO ballot polling method of measuring risk and estimating how many ballots need to be examined.[7] The tool and associated code is open source and may be reviewed here: https://github.com/votingworks/arlo and in the appendix. It was estimated that a sample size of 1,423 ballots would be needed to test a risk-limit of 10%.

This RLA was conducted using the *ballot polling method*. Ballot polling methods check if the outcome of an election is correct, whereas the ballot comparison method assesses if the tabulation was correct. Ballot polling audits are simpler to implement because they require little preparation and virtually nothing from the voting system. They are the most obvious option for any jurisdiction that produces a paper trail. Typically, ballot polling reviews the smallest amount of ballots necessary to produce strong evidence that a reported outcome is correct. Ballot polling methods also work best when elections have margins that are greater than 2%[8], which made it an ideal option in Virginia for auditing both the Presidential and US Senate race. Overall, the ballot polling method was the most practical option for conducting a statewide risk-limiting audit in Virginia. [9]

The following steps were taken by ELECT and election administrators to conduct the audit:

Submit an ELECT 659: Prior to the audit, localities were required to submit an ELECT-659 form. An ELECT-659 is a request to Inspect Sealed Election Materials sent to ELECT for

[7] VotingWorks, Arlo, https://github.com/votingworks/arlo
[8] Pilot Implementation Study of Risk-Limiting Audit Methods in the State of Rhode Island, Report on the Rhode Island RLA Working Group, August 2019, https://www.brennancenter.org/sites/default/files/2019-09/Report-RI-Design-FINAL-WEB4.pdf
[9] Bravo: Ballot-polling Risk-Limiting Audits to Verify Outcomes, Mark Lindeman, Phillip B.Stark, Vincent S. Yates, Department of Statistics, University of California Berkeley, https://www.usenix.org/system/files/conference/evtwote12/evtwote12-final27.pdf

signature authorization to present to the Clerk of the Circuit Courts to access ballots from the 2020 November General Election.[10] A copy of this form is listed in the appendix.

Create a Ballot Manifest: Registrars created a *ballot manifest*. A *ballot manifest* is a two column spreadsheet that includes a list of the "Batch Name" (column A) and the "Number of Ballots" (column B). All types of ballots are included (in person, mail-in, provisional, etc.) in the manifest. The ballot manifest creates an inventory of every ballot in a locality.

Batch Name	Number of Ballots
Pct 101	75
Pct102	112

Upload the Ballot Manifest: Once the ballot manifest was created, localities saved the manifest as a csv file and uploaded the spreadsheet into Arlo, VotingWorks' audit software. General registrars/Director of Elections were automatically enrolled in the open-source software to complete the audit.

Generating a Random Seed Number & Ballot Selection: ELECT and VotingWorks held a virtual public meeting to generate the random seed number. The number was generated by four ELECT staff members rolling a ten-sided die five-times each to create the 20 digit number. The random seed number was entered into the audit system software to generate the list of ballots needed to be examined by each locality.

Ballot Retrieval Lists: Localities, who were selected in the random sample, received a list of ballots to review directly from Arlo. The lists included which batches to open and which ballot to audit. See below:

Batch Name	Ballot Number
Pct 101	17
Pct 102	88

The ballot number reflects the numerical order of a specific ballot. In order to locate ballot number 17, a member of the audit board must count, starting at the top of the stack of ballots, each stored ballot until they reach the 17th ballot in the batch.

Ballot Retrieval Process: Localities had four days to host a public meeting, where ballots were retrieved, tallied and uploaded into Arlo. An Audit Board, consisting of one Democrat and one Republican, retrieved each specified ballot and recorded the results for the office on a tally sheet. The Audit Board inputs the results of the tally sheet into the audit software and submits their results. Some localities in the Commonwealth did not have any ballots pulled in the random sample and therefore did not have to audit any ballots. These localities are listed in the result section of this memo.

[10] Virginia Department of Elections, Memo RE: Statewide Risk Limiting Audit, February 8th, 2021

Public Announcement of Results: A public meeting was held on Tuesday, March 2nd, where Commissioner Christopher Piper, announced the results of the statewide audit.

Results/Findings

The audit confirmed that the original count of the votes accurately reflected the winners in Virginia for both the United States Presidential and Senate races. The risk limit for the audit was met for both races with results falling significantly below the 10% risk limit.

In the US Presidential Race, 1,372 votes were sampled. Of those votes, Biden received 756; Trump received 572, Jorgensen received 25; and Write-ins received 8. This resulted in a .00000065117% chance that the outcome of the Presidential election in Virginia was inaccurate, meaning that election officials are over 99% confident in the reported outcome.

Similarly, the US Senate Race sampled 990 votes. Of those votes, Warner received 559; Gade received 417; Write-Ins received 1. This resulted in a .00000424172% chance that the outcome of the US Senate race was inaccurate, meaning that election officials are over 99% confident in the reported outcome of the election. [11]

Discrepancies

While 1,423 ballots were pulled, some of the ballots retrieved did not include votes for each contest. In a Presidential election year, it is not uncommon for many people to only vote for a candidate for President. Similarly, of the ballots pulled for the US Senate Race, 51 of them did not vote for a Presidential candidate.

Of the 133 localities that uploaded a manifest, 122 were randomly selected for the RLA. The following eleven localities did not have to retrieve ballots during the first statewide RLA:

Bath	Greensville	Lunenburg	Richmond County
Dickenson	Highland	Prince Edward	Emporia
Floyd	Lexington	Radford	

Future Audits

ELECT has access to Arlo, the software used to conduct the 2021 statewide audit, and VotingWorks' services until the end of the calendar year. After the end of the year, ELECT must decide if they will continue use of the VotingWorks software and support to conduct future RLAs.

[11] Results of Risk-Limiting Audit of Nov. 3, 2020 General Election in Virginia, https://www.elections.virginia.gov/rla-results_nov-3-2020/

If ELECT would like to conduct additional RLAs in 2021, it is important to keep the following considerations in mind when selecting a race to be audited:

- The margin of the race.
- Number of ballots in the race.
- Ballot storage across multiple jurisdictions.

ELECT RECOMMENDATION:

VotingWorks suggests that if the number of ballots to be sampled exceeds 15% of the total number of ballots cast than a full hand-recount is recommended. ELECT should focus on RLAs for larger contests as opposed to smaller contests because smaller contests pose challenges due to sample size. For example, the January 5th, 2021 Southampton election for Mayor only had thirty-six ballots cast. In this instance, it makes sense to do a full manual recount. Additionally, ELECT should target races with margins greater than 2%. Smaller margins increase the number of ballots that need to be sampled. Statewide races are also great options for future RLAs because they provide opportunities for all 133 localities to participate. A list of suggested races to audit, along with the pros and cons of each are listed in the appendix.

Conclusion

The first statewide Risk-Limiting Audit in Virginia was a great success and reaffirmed ELECT's dedication to ensuring secure and accurate elections. The results reflect the hard work of election administrators and further exemplifies the integrity and validity of the 2020 November General Election. RLA's are an important tool in reassuring the public that every vote counts and provide an excellent check on the democratic process.

Appendix

i. § 24.2-671.1. Audits of ballot scanner machines.

A. The Department of Elections shall coordinate a post-election risk-limiting audit annually of ballot scanner machines in use in the Commonwealth. The localities selected for the audit shall be chosen at random with every locality participating in the Department's annual audit at least once during a five-year period. The purpose of the audits shall be to study the accuracy of ballot scanner machines.

B. No audit conducted pursuant to this section shall commence until after the election has been certified and the period to initiate a recount has expired without the initiation of a recount. An audit shall have no effect on the election results.

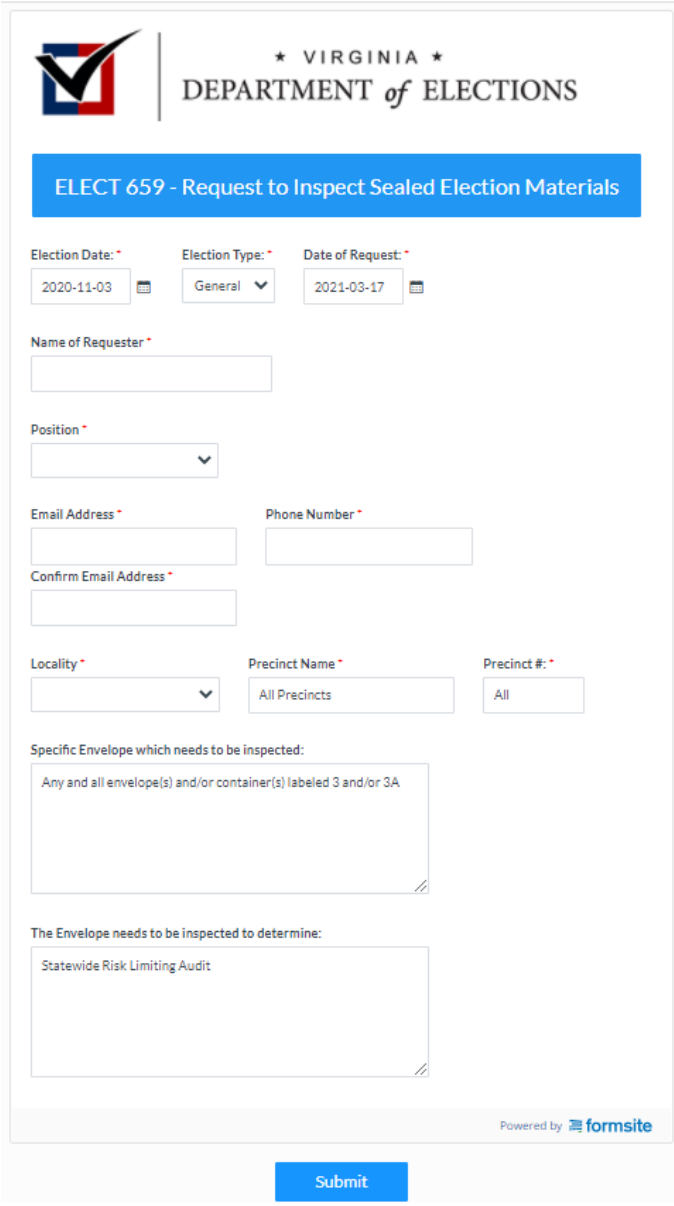
C. All audits conducted pursuant to this section shall be performed by the local electoral boards and general registrars in accordance with the procedures prescribed by the Department. The procedures established by the Department shall include its procedures for conducting hand counts of ballots. Candidates and political parties may have representatives observe the audits.

D. The local electoral boards shall report the results of the audit of the ballot scanner machines in their jurisdiction to the Department. At the conclusion of each audit, the Department shall submit

a report to the State Board. The report shall include a comparison of the audited election results and the initial tally for each machine audited and an analysis of any detected discrepancies.

2008, c. 565; 2014, cc. 540, 576; 2017, c. 367.[12]

ii. ELECT 659 – Request to Inspect Sealed Election Materials



★ VIRGINIA ★
DEPARTMENT *of* ELECTIONS

ELECT 659 - Request to Inspect Sealed Election Materials

Election Date: * 2020-11-03
Election Type: * General
Date of Request: * 2021-03-17

Name of Requester *

Position *

Email Address *
Phone Number *
Confirm Email Address *

Locality *
Precinct Name * All Precincts
Precinct #: * All

Specific Envelope which needs to be inspected:
Any and all envelope(s) and/or container(s) labeled 3 and/or 3A

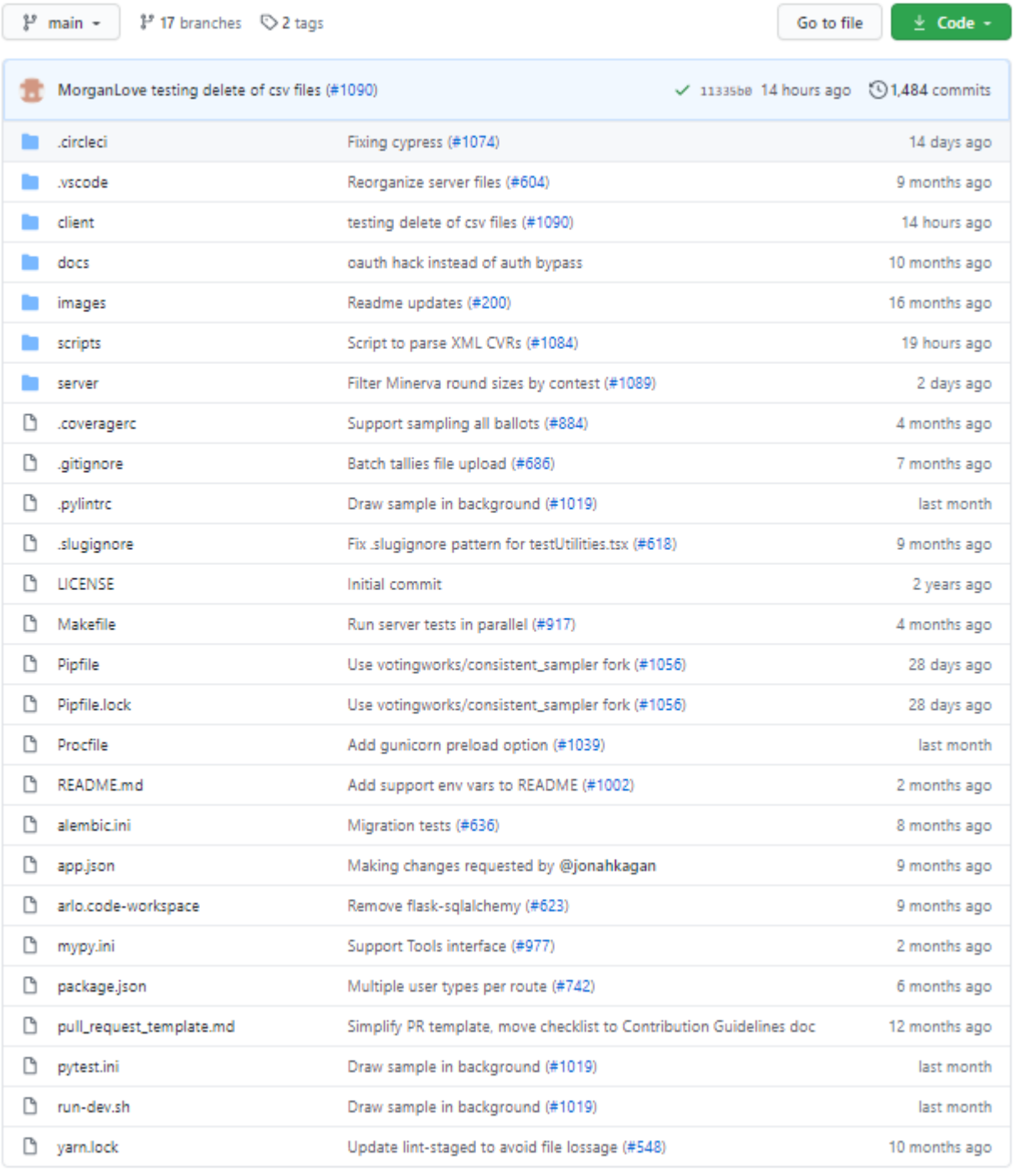
The Envelope needs to be inspected to determine:
Statewide Risk Limiting Audit

Powered by formsite

Submit

[12] Code of Virginia, § 24.2-671.1, https://law.lis.virginia.gov/vacode/title24.2/chapter6/section24.2-671.1/

iii. **Code**



main · 17 branches · 2 tags · Go to file · Code

MorganLove testing delete of csv files (#1090) — 11335b0 14 hours ago — 1,484 commits

.circleci	Fixing cypress (#1074)	14 days ago
.vscode	Reorganize server files (#604)	9 months ago
client	testing delete of csv files (#1090)	14 hours ago
docs	oauth hack instead of auth bypass	10 months ago
images	Readme updates (#200)	16 months ago
scripts	Script to parse XML CVRs (#1084)	19 hours ago
server	Filter Minerva round sizes by contest (#1089)	2 days ago
.coveragerc	Support sampling all ballots (#884)	4 months ago
.gitignore	Batch tallies file upload (#686)	7 months ago
.pylintrc	Draw sample in background (#1019)	last month
.slugignore	Fix .slugignore pattern for testUtilities.tsx (#618)	9 months ago
LICENSE	Initial commit	2 years ago
Makefile	Run server tests in parallel (#917)	4 months ago
Pipfile	Use votingworks/consistent_sampler fork (#1056)	28 days ago
Pipfile.lock	Use votingworks/consistent_sampler fork (#1056)	28 days ago
Procfile	Add gunicorn preload option (#1039)	last month
README.md	Add support env vars to README (#1002)	2 months ago
alembic.ini	Migration tests (#636)	8 months ago
app.json	Making changes requested by @jonahkagan	9 months ago
arlo.code-workspace	Remove flask-sqlalchemy (#623)	9 months ago
mypy.ini	Support Tools interface (#977)	2 months ago
package.json	Multiple user types per route (#742)	6 months ago
pull_request_template.md	Simplify PR template, move checklist to Contribution Guidelines doc	12 months ago
pytest.ini	Draw sample in background (#1019)	last month
run-dev.sh	Draw sample in background (#1019)	last month
yarn.lock	Update lint-staged to avoid file lossage (#548)	10 months ago

iv. 2021 RLA's: Potential Races

Locality	Contest	Date	Outcome	Analysis
7th Congressional District	US House of Representatives7th Congressional District	November 3rd, 2021	**Total: 454, 339** Spanberger: (50.8%) 230,893 (W) Freitas: (49.0%) 222,623 W/I: (.2) 823	• Larger number of ballots would need to be pulled in order to reach the risk limit for this race. • To reach a 90% risk limit, the initial ballot sample would have to include at a minimum 13,928 ballots. It is assumed, due to the close margin, that multiple samples would have to be conducted thus doubling and tripling this number.[13] • May be quicker to do a full manual tally of this race, due to small margin of victory • Any locality with a split in congressional districts may have stored their ballots within the same batch. The ballot manifest may therefore

[13] Tools for Ballot-Polling Risk-Limiting Election Audits, https://www.stat.berkeley.edu/~stark/Vote/ballotPollTools.htm

				include ballots from other races. The sample has the potential to pull ballots that may not have the race on them further complicated the RLA process.
Norfolk City, Prince William County, Stafford County, Virginia Beach County	House of Delegates 002; House of Delegate Race 090	January 5th, 2021	**002: 4,451** (51.74%), 4,143 (48.16%), W/I 9 (.10%) **090: 3,691** (63.52%), 2,114 (36.38%) W/I 6 (.10%)	A full-hand count makes more sense in this race, given the limited number of ballots
Prince William County	Commissioner of Revenue; Treasurer; School Board	February 2nd, 2021	**Commissioner of Revenue: 843** (83.7%), 76 (7.55%), 64 (6.36%), W/I 24 (2.38%) **Treasurer: 217** (19.85%), 871 (79.69%), W/I 5 (6.46%) **School Board for 4th District:** 175 (99.77%), W/I (2.23%)	A full-hand count makes more sense in this race, given the limited number of ballots
Southampton	Mayor	February 9th, 2021	**Mayor:** 36 (100%)	A full-hand count makes more sense in this race, given the limited number of ballots
Bland, Buchanan, Dickenson, Montgomery,	38th Senate District	March 23rd, 2021	TBD	This race would make an ideal candidate. It includes Dickenson County, which was not

Norton City, Pulaski, Radford City, Russell, Smyth, Tazewell				previously audited. This audit could be concluded before the 2021 November Election and after results are certified. Possible complications include small turnout and unknown margin.
Culpeper	Clerk of Court	March 30th, 2021	TBD	Margin unknown at this time.
Statewide	June Republican and Democratic Primaries	June 8th, 2021	TBD	Margin unknown at this time.
Statewide	Gubernatorial, Lieutenant Governor and Attorney General	November 2nd, 2021	TBD	Margin unknown at this time.

v. Glossary of Terms

Incorrect Outcome means an electoral outcome that differs from the outcome that would be found by a full manual tabulation of the votes on all ballots validly cast in the election.

Post-election Audit means a process conducted after an election to confirm the accurate reporting of the results of the election

Pre-Certification Audit means a post-election audit conducted prior to the state certification of the election results.

Risk-Limiting Audit of an election is a post-election, pre-certification audit with a pre-specified minimum probability of requiring a full hand tabulation of votes on all ballots validly cast in an election contest if the outcome reported by the voting system is incorrect. It involves hand-to-eye examination of printed ballots until there is strong statistical evidence that the reported election outcome is correct, or in the absence of such evidence, escalates to a full manual count of ballots to determine the election outcome.

Risk Limit of a risk-limiting audit is the largest probability that the audit will fail to correct an election outcome that is incorrect.

Ballot Manifest is a two column spreadsheet created by localities that includes a list of the "Batch Name" (column A) and the "Number of Ballots" (column B). All types of ballots are included (in person, mail-in, provisional, etc.) in the manifest. The ballot manifest creates an inventory of every ballot cast in a locality.

Random Seed Number A random number sequence that is created and used to generate the ballots selected for auditing.

Ballot-Polling Audit a type of RLA in which individual paper ballots are randomly selected to confirm that the overall results of an election were correctly reported.

Ballot-Comparison Audit a type of RLA in which individual paper ballots are randomly selected, the voter intent is manually interpreted and compared with the voting system's interpretation of the same ballot, as reflected in the cast vote records.

vi. Arlo Results

Contest Name	Sample Size	Risk Limit Met?	P-Value	Audited Votes
President	1372	Yes	6.51E-06	Biden: 2413568; Trump: 1962430; Jorgensen: 64761; Write-In: 19765
US Senate	990	Yes	4.24E-05	Warner: 559; Gade: 417; Write-In: 1