Maryland State Board of Elections

Post-Election Tabulation Audit Pilot Program Report

MARYLAND.GOV

October 2016

151 West Street, Suite 200, Annapolis, Maryland 21401
Phone: 410-269-2840 E-Mail: info.sbe@maryland.gov

Table of Contents

Acknowledgements

We would like to acknowledge the following for their assistance and support during the post-election tabulation audit pilot program:

Linda Lamone, State Administrator, for authorizing the pilot program and for her commitment to keeping Maryland at the forefront of election innovation and administration.

The staff at the State Board of Elections, especially Natasha Walker, for her invaluable technical knowledge and guidance throughout the pilot program.

The Carroll County Board of Elections, Katherine Berry, Election Director and Paula Troxell, Deputy Director, for generously volunteering to serve as a pilot county and for providing valuable feedback on the piloted audit methods. Additional thanks to the Carroll County Board of Elections staff members who took time to participate in the pilot program.

The Montgomery County Board of Elections, Margaret Jurgensen, Election Director and Alysoun McLaughlin, Deputy Director, for generously volunteering to serve as a pilot county and for providing valuable feedback on the piloted audit methods. Additional thanks to the Montgomery County Board of Elections staff members who took time to participate in the pilot program.

Special thanks to Stuart Harvey, Election Director and Noreen Schultz, Deputy Director, Frederick County Board of Elections, and Katie Brown, Election Director and Rena' Waggoner, Deputy Director, Baltimore County Board of Elections for lending their expertise and volunteering to participate in the pilot audits conducted at the Carroll County Board of Elections.

The University of Baltimore's Schaeffer Center for Public Policy and Dr. Dennis McGrath, for performing the necessary statistical calculations and accompanying analysis and for providing valuable suggestions on the statistical and other components of the pilot program.

Clear Ballot, especially Ana Maria Quevedo and Bill Murphy, whose knowledge and flexibility were instrumental in conducting the automated independent audit pilot.

Nikki Baines Charlson, Deputy State Administrator
Amanda S. La Forge, Pilot Project Manager

Pilot Project Leadership

Nikki Baines Charlson

Since joining the Maryland State Board of Elections (SBE) in 2002, Ms. Charlson has been involved with implementing the requirements of the federal Help America Vote Act of 2002. She was appointed Deputy Administrator in September 2013 and assists the State Administrator with managing the office and overseeing the administration of elections in Maryland, including the recent implementation of a new voting system and same day registration and address changes during early voting.

Prior to her appointment as the Deputy Administrator, Ms. Charlson served as SBE's Director of Election Reform & Management and was involved in projects including the implementation of a HAVA-compliant voting system and voter registration system, election official and public education, and improving accessibility of the electoral process for individuals with disabilities. She helped develop and implement SBE's first comprehensive post-election audit and oversaw the development and implementation of SBE's suite of accessible online services, including online voter registration and online ballot delivery. Ms. Charlson is a member of the U.S. Election Assistance Commission's (EAC) Standards Board, which reviews federal voting system standards and evaluates guidance and best practices issued by the EAC.

Amanda S. La Forge

Amanda S. La Forge is an attorney and consultant. Until 2014, she was of counsel to the firm Sandler Reiff Lamb Rosenstein & Birkenstock, P.C. where she advised firm clients in the areas of election law, campaign finance, non-profit taxation and governance, and contractual and commercial matters affecting

organizations in the political arena. She also represented firm clients in civil litigation in these areas.

From 2004 to 2009, Ms. La Forge served as Chief Counsel to the Democratic National Committee, where she provided advice and counsel to national party staff and officers on a wide range of issues including federal and state campaign finance and election law, contracts, employment law and litigation. Earlier in her career, Ms. La Forge worked in the Office of the Secretary of State in Annapolis and in the Civil Litigation Division in the Office of the Attorney General in Baltimore, where she represented the State of Maryland before trial and appellate courts and served as counsel to the Baltimore City Board of Elections.

Ms. La Forge has extensive campaign and voter protection experience and served as the Voter Protection Director for the Maryland Democratic Party in both the 2010 and 2012 election cycles. In 2014, she served as counsel to Maryland's Democratic gubernatorial candidate. She is the co-author, with Joseph E. Sandler, of Recent Developments in Maryland Campaign Finance Law, Maryland Bar Journal, Volume XLVIII, No. 2 (March/April 2015) and the author of The Toothless Tiger: Structural, Political and Legal Barriers to Effective FEC Enforcement, 10 Admin. L.J. Am. U 351 (1996).

I. Introduction

This report summarizes the findings of the post-election tabulation audit pilot program ("the pilot program") conducted by the staff of the Maryland State Board of Elections ("SBE") in Carroll and Montgomery Counties following the April 2016 Primary Election. The goal of the pilot program was to evaluate feasible post-election tabulation audit methods and, based on the practical experiences of the pilot jurisdictions, to select the most cost-effective, efficient and accurate audit method for use after the November 2016 General Election.

Post-election tabulation audits are used to verify and confirm the accuracy of a voting system's reported results. A post-election tabulation audit serves to ensure that the voting system is accurately tallying ballots and that the winners of each contest are called correctly, without regard to the closeness of any particular contest. A post-election audit is *not* a recount or a re-canvass of the votes. Rather, the audit concerns itself with the actual performance of the voting system, based on the actual votes cast by voters. When used in conjunction with pre-election logic and accuracy testing ("L&A"), post-election tabulation audits serve to increase public confidence in election results, election administration and the democratic process.[1]

While there are many schools of thought on the "right" or "best" way to conduct a post-election tabulation audit, there is no real consensus among election administrators, academic experts, policy-makers or legislators as to a single, most accurate or most effective post-election audit methodology. As a result, election districts throughout the country use a variety of methods to conduct post-election tabulation audits based on their priorities and the capabilities and limitations of their voting systems.[2] Regardless of the audit methodology used,

[1] SBE and the LBEs currently conduct a comprehensive audit of election practices and procedures following each election. The goal of this comprehensive audit is to protect and ensure the integrity of the election process before the local boards of canvassers certify the election. It includes a review of 15-20 tasks performed by the LBEs. A post-election tabulation audit will be added to this comprehensive audit.

[2] For example, Florida counties can chose to conduct either an independent, automated audit or a manual, hand-count fixed percentage audit. § 101.591 Fla. Stat. (2016). New York similarly

the goal of a post-election tabulation audit remains the same: to verify the accuracy of the primary voting system's reported results, thereby increasing confidence in those results.

An important feature of Maryland's new paper-based voting system (Election System & Software's ("ES&S") EVS 5.2.0.0), first implemented during the April 2016 Primary Election, is its ability to capture an image of each voted ballot when the paper ballot is fed through the scanner at the voting location or at the local board, in the case of absentee and provisional ballots. This feature means that election results can be audited at a ballot level, which was not an option under the previous voting system, while eliminating the need for election officials to physically handle or count voted ballots unless a petition for recount or other judicial challenge is granted.

In an effort to take advantage of this newly available functionality, and to fulfill its legislative mandate to maximize the use of technology in election administration,[3] SBE issued a Request for Information ("RFI") in November 2015 seeking information regarding the functionality and costs of existing products associated with the independent electronic verification of voting results. In December 2015, SBE began developing a pilot program to test different types of post-election tabulation audits.

Following the 2016 General Assembly Session, the Joint Chairmen's Report on the Fiscal 2017 State Operating Budget included an amendment to SBE's general fund appropriation stating that $50,000 of the appropriation "may not be expended until a post-election tabulation audit following the 2016 general election . . . is completed and the State Board of Elections [] submits a report" to the House Appropriations and Ways and Means Committees and the Senate

allows counties to choose independent, automated audits. NY Elec. Law § 9-211 (2016). The Ohio Secretary of State requires counties to use either a manual fixed percentage audit or a Risk Limiting Audit. Directive 2014-36. Pennsylvania allows counties to choose manual or electronic audits. 25 P.S. § 3031.17. In addition, at least 20 states do not conduct any kind of post-election tabulation audit or only conduct post-election tabulation audits under certain circumstances. *See http://www.ncsl.org/research/elections-and-campaigns/post-election-audits635926066.aspx*

[3] Md. Code Ann. Election Law § 2-102(a)(7).

Budget and Taxation and Education, Health and Environmental Affairs Committees.

The development, implementation and results of the pilot program are discussed below.

II. Types of Post-Election Tabulation Audits

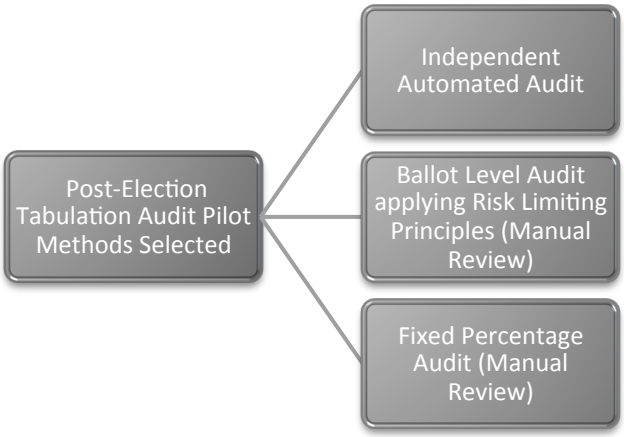
In developing the pilot program, the SBE researched and evaluated the different types of post-election tabulation audit methods, including those used in other jurisdictions. The evaluation and selection of pilot methods were guided by the following criteria:

- Maximize the technological functions of the new voting system;
- Minimize human error and eliminate chain of custody issues by using securely stored ballot images, rather than actual voted paper ballots;
- Minimize the use of valuable staff time at the Local Boards of Elections ("LBEs") in the days following an election;
- Complete the audit prior to legally binding local certification and swearing-in deadlines;[4]
- Be conducted at the ballot-level, *i.e.* tally actual voted ballot images to audit the voting system results; and

[4] County boards of canvassers must certify election results no later than the second Friday after the election, or if the canvass is completed after that date, within 48 hours of the completion of the canvass. Md. Code Ann. Elec. Law § 11-401(c)(1). Note that during the time prior to certification, the LBEs also conduct two absentee ballot canvasses and a provisional ballot canvass. In addition, in many counties, county charters establish December 1 as the swearing-in date for county officials.

- Be entirely independent of the primary voting system.

Following its research, evaluation and guiding criteria, SBE decided to pilot the three (3) post-election tabulation audit methods diagramed and described briefly below.



Independent Automated Audit

An independent automated audit relies solely on the use of independent software to tabulate ballot images. The results from the independent tabulation are then compared to the tabulation results from the voting system. Any variances between the two tabulations are identified and resolved by LBE staff members.

For the pilot program, SBE contracted with the Boston-based elections technology company Clear Ballot and used its ClearAudit software product.[5] ClearAudit is the only currently available, market-ready software product that can perform an independent automated post-election tabulation audit using ballot images imported from another voting system.

[5] For more information about Clear Ballot and its ClearAudit solution, visit *www.clearballot.com*.

Ballot Level Audit Applying Risk Limiting Principles

Risk-Limiting Audits ("RLAs") are evidence-based tabulation audits concerned with confirming the correct winner of any particular contest. In an RLA, the audit tabulation stops as soon as it becomes statistically implausible that a full recount would alter the result of the election. When the margin of victory in any particular contest is large enough, very small sample sizes can be used to achieve high statistical confidence that the results reported by the primary voting system are correct. As the margin of victory becomes smaller, however, larger sample sizes are needed to achieve the desired level of confidence in the voting system results. In this audit method, a very close election may mean that the sample size equals all ballots cast in that contest.

The use of RLAs has been pioneered by Dr. Phillip Stark, a statistician at the University of California at Berkeley, who has made his RLA audit tools and formulae available to the public.[6] A "true" RLA requires using voted paper ballots stored in the order in which the ballots were voted. Out of concern for voter privacy, Maryland's new voting system does not keep voted ballots in sequential order but rather randomizes both voted paper ballots and the images of those ballots. Accordingly, while it was not possible to pilot a "true" RLA in Maryland, RLA principles were applied to a ballot-level audit.

Fixed Percentage Audit

A fixed percentage post-election tabulation audit audits a randomly selected percentage of all ballot images cast, regardless of jurisdiction size or margin of victory. For the pilot program, SBE decided to audit 1% of the precincts in each pilot county, where 100% of the ballot images from those precincts would be tabulated. In Carroll County, which has 35 precincts, one randomly selected precinct was audited. In the interest of conserving valuable staff time, SBE fully audited one randomly selected precinct in Montgomery County (which with 254 precincts would require 3 precincts to be audited to reach 1%) and gathered

[6] Available at *http://www.stat.berkeley.edu/~stark/Vote/auditTools/htm.*

data from an additional 125 ballot images from a second precinct. Using the data collected, SBE was able to estimate the time and cost of an audit of 1% of precincts in Montgomery County.

III. Pilot Program Description & Implementation

Independent Automated Audit

The first phase of the pilot program launched in April 2016 when SBE entered into an agreement with Clear Ballot to use its ClearAudit software to conduct independent automated audits of the 2016 Primary Election results in both Carroll and Montgomery Counties.

In May 2016, staff at the Carroll and Montgomery Boards of Election provided SBE staff with the necessary data to conduct the audits. SBE staff in turn transmitted this and other data to Clear Ballot. This data included:

- PDFs of all printer-ready primary ballot styles for both counties;[7]
- Election results reports generated by the primary voting system (EL30A reports); and
- Unencrypted images of all voted ballots from the primary election.

Upon receipt of the data, Clear Ballot created "Ballot Definition Files" (BDFs) for both counties, analyzed and processed ballot images, converted the ballot images into raw image files, ran the ClearAudit tabulator on all ballot images, created a "Comparison Results File" (CRF) for both counties based on the EL30A reports and resolved any unreadable ballot images from both counties. The Clear Ballot Post Project Review, which provides a detailed technical review of the process, is attached at Appendix A.

[7] SBE is responsible for creating all ballot styles used by the LBEs and sending those ballot styles to the printer.

The results of Clear Ballot's independent automated audit confirmed all of the results reported by the primary voting system. The most common differences between Clear Ballot's audit solution and the primary voting system stemmed from ballots that were improperly scanned (*i.e.* crooked), low resolution ballots, and unreadable or invalid marks made by the voter on the ballot. Tabulation differences regarding the way a voter marks the ballot are caused by algorithmic variations between the two systems (*e.g.,* one system "counts" a lighter shaded oval, while the other does not; or one system "counts" a mark that strays outside of the oval, while the other does not). Sample ballot images that were counted differently by the two systems are attached at Appendix B.

All 47,540 images of the ballots cast in Carroll County were successfully imported into the ClearAudit system.[8] Of those, 289 ballot images (.6%) were identified as unreadable by ClearAudit for the reasons outlined above. Following the review and reconciliation process conducted by Clear Ballot staff, zero ballot images remained unresolved, meaning that upon further review, any differences between the two tabulations could be accounted for in a logical and demonstrable manner.

Similarly, all 245,871 images of ballots cast in Montgomery County were successfully imported into the ClearAudit software. Of those, 1,702 ballot images (.7%) were identified as unreadable by ClearAudit. Following the review and reconciliation process, zero ballot images were left unresolved, meaning that upon further review, any differences between the two tabulations could be accounted for in a logical and demonstrable manner.

The results of the pilot independent automated audit were presented by Clear Ballot on June 20, 2016 at two identical presentations at the Maryland Association of Election Officials (MAEO) Annual Meeting in Cambridge,

[8] At the time of the pilot, Clear Ballot's solution was programmed to read and tabulate ballots marked by hand but was not able to read and tabulate ballots marked by the ballot marking device. After validating that the number of ballot images received matched the number of ballots cast in the election, representatives of Clear Ballot manually entered into the ClearAudit solution the votes recorded on the images of the ballots marked by the ballot marking device.

Maryland. The results were presented again on June 30, 2016 at the regular public meeting of the Maryland State Board of Elections in Annapolis.

Data collected from the automated independent audit is presented at Section IV, below.

Ballot Level Audit Applying Risk Limiting Principles & Fixed Percentage Audit

The second phase of the pilot program was conducted on June 27, 2016 in Montgomery County, and on June 28, 2016 in Carroll County. Both a Ballot Level Audit applying Risk Limiting Principles and a fixed percentage audit were piloted in each county. SBE staff worked closely with staff from the LBEs to successfully conduct these pilots. Dennis McGrath, PhD, a statistician and professor at the University of Baltimore, served as a consultant for the statistical portions of the pilot program and conducted all necessary calculations.

Prior to the launch of phase two of the pilot program, SBE made a number of preliminary decisions to streamline and standardize the pilot process. First, using the random selection method of rolling ten-sided dice,[9] where an even number represented Democratic ballots and an odd number represented Republican ballots, it was determined that Republican ballots would be audited in Carroll County and Democratic ballots would be audited in Montgomery County. Note that in a tabulation audit following a general election it would not be necessary to separate ballots by party affiliation.

Second, SBE decided that three contests – U.S. President, U.S. Senate, and U.S. House – would be audited in each pilot county. Because the primary voting system reports results at a countywide level, contests for both the 1st and 8th congressional districts were audited in Carroll County, and contests for the 3rd, 6th and 8th congressional districts were audited in Montgomery County.

Third, SBE developed tally sheets to record the results for each type of audit. Samples of these tally sheets, which reflect improvements suggested by the LBEs following the pilot, are attached at Appendix C. Ten sided dice were purchased

[9] Using ten-sided dice is recommended by statisticians, including Dr. Stark and Dr. McGrath, as a public, transparent, and recordable way to make random selections.

to assist the LBEs with the random selection of precincts for the fixed percentage audit.

Finally, both LBEs were instructed to prepare for the pilot audits by:

- Exporting the Cast Vote Record (CVR) report for the county, filtered by party, and creating separate spreadsheets for each party;
- Exporting the ballot images from the county, sorted by precinct and party; and
- Having computer workstations ready for multiple teams of two, with access to the CVR export and the ballot images.

Ballot Level Audit Applying Risk Limiting Principles

To determine the number of ballots to review, Dr. McGrath first selected the contest where the winner had the smallest margin of victory over his or her opponent. Of the four contests being audited from the 2016 Republican Primary Election in Carroll County (U.S. President, U.S. Senate and the 1st and 8th Congressional Districts), the smallest margin of victory (2,958 votes) was Dan Cox's 5,512 votes over Jeffrey Jones's 2,554 votes. Using Dr. Stark's publicly available tools and formulae, Dr. McGrath determined that 247 ballot images should be reviewed in order to achieve a 95% confidence level that the results reported by the primary voting system were accurate.[10]

Of the five contests being audited from the 2016 Democratic Primary Election in Montgomery County (U.S. President, U.S. Senate and the 3rd, 6th, and 8th Congressional Districts), the smallest margin of victory (8,595 votes) was John Sarbanes's 10,609 votes over John Rea's 2,014 votes. Again, using the publicly available tools and formulae found at Dr. Stark's website, Dr. McGrath determined that 82 ballot images from Montgomery County should be reviewed

[10] Note that if a greater level of confidence, such as 99%, was required, the number of ballot images to be audited would increase. Most jurisdictions that have piloted RLA-style audits have used a 90% confidence rate.

in order the achieve a 95% confidence level that the results reported by the voting system were accurate.

A central feature of Risk Limiting Audit methodology is that as the margins of victory get smaller, the sample sizes get larger. This is why more ballot images had to be tabulated in Carroll County than in Montgomery County.

In order to determine which ballot images to review, ten-sided dice were rolled until a 20 digit random "seed" number was generated. This seed number was then entered into Dr. Stark's tools and used to generate a sequence of pseudo-random numbers. The use of a pseudo-random number generator allows the sequence of numbers to be replicated by anyone using the same seed number, thereby allowing for greater transparency in the process.

When a ballot is scanned, the voting system creates an image of that ballot and assigns the image a unique numeric identifier. The voting system also creates a Cast Vote Record (CVR) for that ballot, which is assigned the same unique numeric identifier as the ballot image. The sequence of numbers generated by the pseudo-random number generator was used to identify the actual CVRs and ballot images that would be reviewed as part of the audit. These lists for both pilot counties are attached at Appendix D.

Ballot images – in batches of 25 – were manually reviewed and tallied by teams of two. One team member opened and displayed the appropriate ballot image on the computer monitor and read the votes cast to the second team member who recorded the votes on the tally sheet. When a batch of 25 ballot images was completed, the tally sheet was given to a second team of two reviewers who compared the tally sheet results to the CVRs for those ballot images. This step confirmed that the voting system had accurately tabulated the ballot. The results of the comparison were also noted on the tally sheet. A sample ballot image and its corresponding CVR are attached at Appendix E.

The Ballot Level Audit applying Risk Limiting Principles confirmed with 95% certainty that the voting system accurately counted the ballot images selected as part of the audit. While there were initially a small number of differences

between the primary voting system results and the audit results in both counties, the differences were statistically insignificant and were the result of human error (numbers being placed on the wrong line of the tally form, arithmetic errors, etc.) and were able to be fully resolved upon review. LBE staff made excellent suggestions to improve the tally sheets and the methods by which the required data was most efficiently exported in advance of the audit.

Data collected from the Ballot Level Audit applying Risk Limiting Principles is presented at Section IV, below.

Fixed Percentage Audit

SBE piloted fixed percentage audit of precincts, where 100% of all ballot images in 1% of randomly chosen precincts in each county were manually reviewed and tallied and compared to the precinct level results reported by the voting system. As described above, one randomly selected precinct was audited in Carroll County and one randomly selected precinct was audited in Montgomery County (where 1% of precincts would have required three precincts be audited) in the interest of conserving valuable staff time. Additional data was also collected from an additional 125 ballot images from a second Montgomery County precinct.

While the precincts in both counties were randomly selected, Dr. McGrath applied statistical methodologies to ensure that each ballot cast in the county had an equal chance of being selected, regardless of the precinct in which the ballot was cast. This meant that larger precincts had a greater chance of being chosen than smaller precincts. Based on the cumulative number of votes cast by precinct, Dr. McGrath assigned a range for each precinct in each county. Using the ten-sided dice, LBE staff rolled a six-digit number and selected the precinct that fell within that range. The charts showing the cumulative vote ranges developed by Dr. McGrath are attached at Appendix F.

Ballot images – in batches of 25 – were manually reviewed by teams of two. Ballot images were reviewed consecutively until all ballot images in the precinct had been reviewed. The first team member opened and displayed on the

computer monitor the ballot image and read the results to the second team member who recorded the results for the given contests on the tally sheet.

When a batch of 25 ballot images was completed, the reviewing team totaled the results for each contest. Once the entire precinct was tallied, the total from each tally sheet was aggregated on a second tally sheet to get data for the entire precinct. This manual tally was then compared to the Precinct Summary Report with Group Detail, which is the report generated by the primary voting system that provides the results from a given precinct.

The fixed percentage audit also confirmed the primary voting system's results from the precincts selected as part of the audit. While a fixed percentage audit cannot provide the same level of confidence as a Ballot Level Audit applying Risk Limiting Principles, one can conclude that the results from the precincts selected accurately reflect the results reported by the voting system for all audited contests and that no systemic discrepancies were present.

Again, in both counties, there were a small number of differences between the voting system results and the audit results found in the first examination of ballot images. Nearly all of these differences were found to be the result of human error (numbers being placed on the wrong line of the tally form, arithmetic errors, etc.) and were fully resolved upon review. In a very small number of cases (approximately 2), the difference could be traced to a mark on the ballot that was ambiguous and was interpreted differently by the voting system and the reviewing team.

Data collected from the fixed percentage audit is presented Section IV, below.

IV. Data Collection from Pilot Program

Carroll County

1. Independent Automated Audit

The table below reflects the staff time at both the Carroll County Board of Elections and SBE to prepare and process the 47,540 ballots that were cast in Carroll County during the 2016 Primary Election for the Independent Automated Audit.

Table 1. Staff Time for Independent Automated Audit

	Carroll County	SBE	Total Staff Time
Sending primary ballot PDFs	0 hours	.08 hour	.08 hour
Sending EL30A reports	.08 hour	0 hours	.08 hour
Sending ballot images	5 hours	1.5 hours	6.5 hours
Export Cast Vote Record, filtered by party, create spreadsheets	3.5 hours	0 hours	3.5 hours
Export ballot images, sorted by precinct and party	1 hour	0 hours	1 hour
Total Time	9.58 hours	1.58 hours	11.16 hours

2. Ballot Level Audit Applying Risk Limiting Principles

The table below reflects the staff time at the Carroll County Board of Elections to review the 247 ballots in the Ballot Level Audit applying Risk Limiting Principles using the two-step process described above. The average total review time for a batch of 25 ballot images was 25 minutes and 45 seconds, or approximately one minute per ballot image.

Table 2. Ballot Level Audit Applying RLA Principles (time in minutes)

	Manual Count	CVR Verification	Batch Review Time
Batch 1†	23:53 minutes	10:16 minutes	33:69 minutes
Batch 2	20:43	7:45	27:88
Batch 3	16:15	7:32	23.47
Batch 4*	24:07	--	--
Batch 5	23:08	3:37	26:45
Batch 6	17:37	5:07	22:44
Batch 7	18:51	15:07	33:58
Batch 8	15:06	4:27	19:33
Batch 9	14:29	2:47	16.76
Batch 10*	17:03	8:17	--
Average Review Time Per Batch	18:45	7:44	25:45 minutes

† Batches contained 25 ballot images.
* The time reported for Batch 4 is the combined time for manual counting and CVR verification. Batch 10 contained only 22 ballot images. As a result, Batch 4 and Batch 10 data are not included in the "average review time" data.

3. Fixed Percentage Audit

The table below reflects the staff time at the Carroll County Board of Elections to review all 137 Republican ballot images from a randomly chosen precinct (#05-06). Ballot images were reviewed and tallied by teams of two. The average review time to manually review and tally a batch of 25 ballot images was approximately 14 minutes, or 34 seconds per ballot image.

Table 3. Fixed Percentage Audit (time in minutes)

	Manual Count and Tally
Batch 1†	14:18
Batch 2	15:10
Batch 3	15:11
Batch 4	11:31
Batch 5	13:58
Batch 6*	5:18
Average Review Time Per Batch	14:01

† Batches contained 25 ballot images.
* Batch 6 contained only 12 ballot images. As a result, Batch 6 data are not included in the "average review time" calculation.

Montgomery County

1. Independent Automated Audit

The table below reflects the staff time at both the Montgomery County Board of Elections and SBE to prepare and process the 245,871 ballots that were cast in Montgomery County during the 2016 Primary Election for the Independent Automated Audit.

Table 4. Staff Time for Independent Automated Audit

	Montgomery County	SBE	Total Staff Time
Sending primary ballot PDFs	0 hours	.17 hour	.17 hour
Sending EL30A reports	.05 hour	0 hours	.05 hour
Sending ballot images	13.5 hours	3 hours	16.5 hours
Export Cast Vote Record, filtered by party, create spreadsheets	.75 hour	0 hours	.75 hours
Export ballot images, sorted by precinct and party	9 hours	0 hours	9 hours
Total Time	23.3 hours	3.17 hours	26.47 hours

2. Ballot Level Audit Applying Risk Limiting Audit Principles

The table below reflects the staff time at the Montgomery County Board of Elections to review the 82 ballots in the Ballot Level Audit applying Risk Limiting Principles using the two-step process described above. The average total review time for a batch of 25 ballot images was 37 minutes and 23 seconds, or approximately 1.5 minutes per ballot image.

Table 5. Ballot Level Audit Applying RLA Principles (time in minutes)

	Manual Count	CVR Verification	Batch Review Time
Batch 1†	23:37 minutes	16:16 minutes	39:53 minutes
Batch 2	23:40	18:03	41:43
Batch 3	21:39	9:35	30:74
Batch 4*	6:26	3:57	9:83
Average Review Time	22:58	14:38	37:23

† Batches contained 25 ballot images.

* Batch 4 contained only 7 ballot images. As a result, Batch 4 data are not included in the "Average Review Time" calculation.

3. Fixed Percentage Audit

The table below reflects the staff time at the Montgomery County Board of Elections to review all 107 Democratic ballot images from one randomly chosen precinct (#09-10) as well as the staff time to review 125 Democratic ballot images (from a total of 327) from a second randomly selected precinct (#11-00). Ballot images were reviewed and tallied by teams of two. The average review time to manually review and tally a batch of 25 ballot images was approximately 7.8 minutes or 31 seconds per ballot.

Table 6. Fixed Percentage Audit (time in minutes)

	Manual Count and Tally
Batch 1 (09-11) †	7:09
Batch 2 (09-11)	7:26
Batch 3 (09-11)	11:02
Batch 4 (09-11)	10:28
Batch 5* (09-11)	2:17
Batch 6 (11-00)	6:42
Batch 7 (11-00)	7:46
Batch 8 (11-00)	6:17
Batch 9 (11-00)	7:19
Batch 10 (11-00)**	9:54
Average Review Time Per Batch	7.86

† Batches contained 25 ballot images.
* Batch 5 contained only 7 ballot images. As a result, Batch 5 data are not included in the "Average Review Time" calculation.
* * Batch 10 includes the time to add totals for each tally sheet and for the batch once the review has been completed. As a result, Batch 10 data are not included in the "Average Review Time" calculation.

V. Assessment & Costs

All three piloted methods confirmed the accuracy the voting system's reported results for all audited contests in both counties. Any differences between the results reported by the voting system and the three piloted audit methods were immaterial with respect to the reported outcomes and were able to be fully resolved in a clear, transparent and understandable manner. Such differences would easily be able to be demonstrated and explained to members of the public, candidates or other observers, regardless of which audit method is used. There were, however, different costs as well as advantages and disadvantages to each of the piloted audit methods. These are discussed below.

Independent Automated Audit

Independent automated tabulation audits have the advantage of being independent of the primary voting system and eliminating the subjective and error-prone human element present in manual audit methods. Academic research regarding error rates during manual post-election tabulation audits has indicated that error rates can be as high as 2%.[11] An independent, automated audit fulfills SBE's legislative mandate to maximize the use of technology in election administration and, unlike a Ballot Level Audit applying Risk Limiting Principles or a fixed percentage audit, an independent automated audit provides the most comprehensive audit of reported election results because 100% of ballots in 100% of all contests are re-tabulated.

In addition, the speed with which an independent automated audit can be performed provides the public, candidates and other interested parties the timely reassurances they seek regarding the performance of the voting system, *before* the LBEs are required to certify the election results. Finally, the manner in which ballot images can be reviewed through a single portal of the ClearAudit software makes it the most user-friendly of all three piloted methods.

The ClearAudit tool also confers some additional benefits not offered by either manual audit method, namely the ability to improve training for election judges as to how to instruct voters to properly mark ballots (by identifying patterns in ballot marking from particular precincts) and as to how to clean and maintain scanners at voting locations (by identifying voting locations with crooked or low resolution ballots).

The greatest disadvantage of the ClearAudit solution is the cost. The propriety software is the only one of its kind currently on the market and is expensive. The cost for software and unlimited technical support for the pilot program was $75,000 for two counties (after a $100,000 pilot program discount was applied). In addition, Carroll County and SBE staff spent approximately 11 hours at a cost of $251.74 in staff time to prepare for the audit, and Montgomery County and

[11] *See e.g., https://www.sciencedaily.com/releases/2012/02/120202151713.htm.*

SBE staff spent approximately 26 hours at a cost of $799.97 in staff time to prepare for the audit.

Once the necessary data was supplied, Clear Ballot was able to tabulate and reconcile all 293,411 ballot images from both counties in approximately two business days. The subsequent review and analysis of the results from the primary voting system and the ClearAudit solution took approximately an additional two business days.[12]

SBE has received a proposal from Clear Ballot to conduct a comprehensive statewide independent automated audit for the 2016 General Election for a cost of $275,000. The estimated cost per ballot image is $.09.[13] At $.09 per ballot image, based on 2014 General Election turnout figures, the cost per county would range from $459.81 (Somerset County) to $19,038.06 (Montgomery County). These costs would not include the staff time required in each county to prepare for and provide the necessary data and ballot images to Clear Ballot prior to the audit, which would vary based turnout by county.

Ballot Level Audit Applying Risk Limiting Principles

A Ballot Level Audit applying Risk Limiting Principles has the advantage of being a ballot-level audit that is independent of the primary voting system. The greatest advantage of a Ballot Level Audit applying Risk Limiting Principles is that in contests with a wide margin of victory, an entire contest can be effectively audited using a very small number of ballot images, thereby saving significant staff time and resources. An additional advantage of a Ballot Level Audit applying Risk Limiting Principles is that, even if a small number of ballot images is audited, the ballot images are selected from a variety of precincts across the jurisdiction. This provides a more diverse and robust verification of the election results than using a fixed percentage audit.

[12] Note that for the pilot program, Clear Ballot reviewed and reconciled *every* unreadable ballot image. If ClearAudit is implemented as the post-election tabulation method, SBE, like other jurisdictions, will set an acceptable variance level (*e.g.* 0.5%) and only unreadable ballot images exceeding that variance level will be reviewed, thereby reducing the overall review time.

[13] This cost per ballot assumes that 3 million ballots will be cast in the 2016 General Election.

During the pilot in Carroll County, three teams of two LBE employees reviewed the required 247 Republican primary ballots. The average time it took for each team of two to manually review a batch of 25 ballot images was 18 minutes and 45 seconds. The average time it then took a second team of two to verify a batch of 25 ballot images against the corresponding Cast Vote Record (CVR) was 7 minutes and 44 seconds. The total batch review time (manual review plus comparison to the CVR) was 25 minutes and 45 seconds, or approximately 1 minute per ballot. The total time to review all 247 ballots was approximately 4.24 hours for 6 employees. *See* Table 2, above.

Using an estimated rate of $15 per person, per hour,[14] it cost approximately $380 for the three teams of two to review the required 247 Republican primary ballots in the primary election. This estimated time does not include the time it took to identify, organize and prepare the selected ballot images for review. Nor does it include the required cost of the services of the statistician (approximately $2600), which would be required each time a Ballot Level Audit applying Risk Limiting Principles were conducted.

During the pilot in Montgomery County, two teams of two LBE employees reviewed the required 82 Democratic primary ballots. The average time it took for each team of two to manually review a batch of 25 ballot images was 22 minutes and 58 seconds. The average time it then took a second team of two to verify a batch of 25 ballot images against the corresponding Cast Vote Record (CVR) was 14 minutes and 38 seconds. The total batch review time (manual review plus comparison to the CVR) was 37 minutes and 23 seconds, or approximately 1.5 minutes per ballot. Total time to review all 82 ballots was approximately 1.8 hours for four employees. *See* Table 5, above.

Using an estimated rate of $15 per person, per hour, it cost approximately $108 for the two teams of two to review the required 82 Democratic primary ballots in

[14] This rate was selected simply to give some context to the cost of staff review time and would in practice vary greatly by jurisdiction. Some larger counties might use temporary workers to perform the post-election tabulation audit and might pay a lower rate closer to $10/hour. Some smaller counties might need to use permanent, professional staff to conduct the post-tabulation and would pay a rate closer to $20 or $30, particularly if senior staff were used.

the primary election. This estimated time does not include the time it took to identify, organize and prepare the selected ballot images for review. Nor does it include the required cost of the services of the statistician (approximately $2600 the two pilot counties), which would be required each time a Ballot Level Audit applying Risk Limiting Principles were conducted.

While the Ballot Level Audit applying Risk Limiting Principles initially appears to be more cost effective than the independent automated audit, the greatest disadvantage of the methodology is that it is highly dependent on the margin of victory in any given audited contest. This results in a highly variable number of ballots that must be reviewed following a given election, making it difficult, if not impossible to implement on a statewide basis. LBEs would not be able to accurately budget for post-election tabulation audit costs or anticipate staffing needs because the amount of staff time would vary so widely depending upon the closeness of the contest and the number of ballot images needing review. The planning process for a Ballot Level Audit applying Risk Limiting Principles cannot even begin until the day after the election when the results from election day and early voting are known. A very close margin of victory could actually necessitate almost a complete manual re-tabulation, which would greatly increase the cost of the audit and require days of staff work, possibly compromising the local certification deadline.

The unpredictability and implementation difficulties of a Ballot Level Audit applying Risk Limiting Principles are disqualifying disadvantages. In addition, Ballot Level Audits applying Risk Limiting principles are complex. They require sophisticated statistical calculations, oversight by a statistician and are difficult to explain to candidates, the public and the LBEs that would be required to conduct them.

Fixed Percentage Audit

A fixed percentage audit also has the advantage of being a ballot-level audit that is independent from the primary voting system. In theory it is probably the most straightforward post-election tabulation audit method (simply audit 1% of precincts from each county); however, when properly conducted, it is actually quite variable. This is because despite being randomly selected, each precinct in the county has an equal chance of being chosen for audit. In a county with large precincts (for example, 18 of Carroll County's 35 precincts have more than 3,000 registered voters), the chance of randomly selecting a large precinct is the same as selecting a smaller precinct. The larger the size of the precincts randomly selected, particularly in a county where more than one precinct must be audited to reach the 1% rate, the higher the cost (in both time and dollars) of the audit.

In addition, a fixed percentage audit of precincts does not generate the same high level of confidence as a Ballot Level Audit applying Risk Limiting Principles because it only audits all of the ballot images from a single (or small number) of all the precincts in that county, while a Ballot Level Audit applying Risk Limiting Principles draws ballot images from multiple precincts throughout the county. A fixed percentage audit can, however, generate some small but important probability that any systemic discrepancies can be found.

In the Carroll County pilot of the fixed percentage audit four teams of two LBE and SBE employees reviewed all of the Republican ballots from the randomly selected precinct #05-06 (137 ballot images). The average time it took to manually review and tally a batch of 25 ballot images was approximately 14 minutes or 34 seconds per ballot image. *See* Table 3, above. Using an estimated rate of $15 per person, per hour, the staff cost was approximately $126. This cost did not include additional time to aggregate all of the tally sheets so that precinct totals could be obtained and compared with the precinct summary report with group detail, nor did it include the services of the statistician (approximately $2600 for two pilot counties).

In the Montgomery County pilot of the fixed percentage audit, four teams of two LBE employees reviewed all of the Democratic ballot images from the randomly selected precinct, 09-10 (107 ballot images). In addition, 125 ballot images (out of 327) from a second randomly selected precinct (11-00) were also reviewed. The average time it took to manually review and tally a batch of 25 ballots images was approximately 7 minutes and 8 seconds, or approximately 17 seconds per ballot image. *See* Table 6, above. Using an estimated rate of $15 per person, per hour, the staff cost for the fixed percentage audit review was approximately $126. This cost did not include additional time to aggregate all of the tally sheets so that precinct totals could be obtained and compared with the precinct summary report with group detail, nor did it include the services of the statistician (approximately $2600 for two pilot counties).

While less variable than a Ballot Level Audit applying Risk Limiting Principles, a fixed percentage audit still maintains enough unpredictability to make it an unappealing choice for a statewide post-election tabulation audit. The likelihood of selecting extremely large precincts is the same as the likelihood of selecting very small precincts, which raises the question of the effectiveness and thoroughness of the methodology – in a general election where over three million ballots are cast, the value of auditing a precinct with 69 ballots in one county to confirm and verify the election results seems dubious at best.

It is also important to note that the pilots of both the Ballot Level Audit Applying Risk Limiting Principles and the fixed percentage audits were conducted in Montgomery and Carroll Counties during a relatively quiet time for LBE administration and staff (June 2016). Both counties used experienced staff and administrators to perform the manual ballot image reviews. In Carroll County, the election directors and deputy directors from both Baltimore and Frederick Counties were present to assist with the pilot.

Neither of these factors would be true if a manual type post-election audit were conducted in the days immediately following a statewide election. Staff would be exhausted, as they typically work 80-hour workweeks in the time leading up to the election. In addition, some LBEs might need to use seasonal or temporary workers to conduct the audit rather than experienced professional staff, if that

permanent staff is required for other post-election responsibilities. As a result, longer ballot image review times and more human tabulation and other errors would almost certainly occur, thereby increasing the cost and time of the audit. This would be particularly important in the context of the certification window that the LBEs have to certify election results.

VI. Conclusion and Recommendation

Upon the conclusion of a successful pilot program, it is recommended that an independent, automated audit using Clear Ballot's ClearAudit solution be implemented statewide following the 2016 General Election. This comprehensive post-election tabulation audit method maximizes the use of technology in election administration, minimizes human error and handling of official election materials, including voted ballots, and provides the fastest, most visual and transparent presentation of audit results which can easily be shared with the public, candidates and other interested parties through a single portal. The poll worker training and equipment maintenance feedback provided by the ClearAudit solution are additional benefits that will lead to more effectively conducted elections in Maryland. It is further recommended that the ClearAudit solution be used in the 2016 General Election only, leaving SBE with the flexibility to select another available independent, automated audit solution should one become available before the 2018 election cycle.

Appendix A

Post Project Review

Maryland SBE Independent Automated Post-Election Audit Pilot Program

Maryland State Board of Elections
151 West Street, Suite 200
Annapolis, Maryland 21401

July 07, 2016

Clear Ballot Group, Inc.
7 Water Street, Suite 7
Boston, MA 02109

www.clearballot.com

Table of Contents

Project Summary

Clear Ballot, upon successfully meeting a SBE RFI selection criteria, was selected to participate in a post-election independent audit pilot following the April 26, 2016 Primaries. The main goal of the independent audit pilot was to "confirm the primary voting system's performance" as stated in the existing Scope of Work. To conduct the audits, Clear Ballot processed ballot images produced by the existing voting system (ES&S ElectionWare). The results of the audit pilot were presented at the MAEO conference, on June 20, and to the Maryland State Board of Elections meeting on June 30, 2016.

Two counties were selected to participate in the pilot, Montgomery and Carroll Counties. The two counties provided Clear Ballot the necessary data files; Primary ballot PDFs, election results reports (EL30A), and unencrypted images of all voted ballots during the Primary election. Clear Ballot prepared a set of Ballot Definition Files (a.k.a BDF) for each county which served as ClearAudit's independent election coding. Once the ClearAudit independent election database was created, the images of voted ballots were imported for tabulation, ballot reconciliation, and generation of vote comparison reports. Per the project Scope of work, Clear Ballot hosted the Montgomery and Carroll Counties audit databases.

The scope of this project included a phased approach for the design, testing, customer trials, and resulted in a successful analysis of Montgomery and Carroll County election files. Our highly automated audit tool minimized the amount of effort required by the participating counties.

A summary of Clear Ballot's phased approach follows:

- Parse the Primary ballot PDFs to map contests, candidates and their relative positions in each ballot style
- Create BDF for both Carroll and Montgomery counties
- Analyze and process the ES&S PDF embedded-image file format produced by ES&S tabulators
- Learn about ES&S image file naming
- Develop procedures/scripts to convert the ES&S PDF image files into raw image files, renamed as required for ClearAudit
- Run ClearAudit tabulator on all images for Carroll and Montgomery counties.
- Create Comparison Results File (CRF) for both Carroll and Montgomery counties, based on ES&S EL30A reports provided to us
- Manually resolved "Unreadable" ballot images in Carroll's and Montgomery's election.
- Reviewed audit results with State Board of Elections and participating counties

Even though the ExpressVote ballots were not part of the audit pilot, Clear Ballot was able to manually resolve and include all ExpressVote ballots into the ClearAudit databases to successfully audit the entire election including all precincts and all ballot types across all voting methods.

On June 1st, Clear Ballot completed the data migration and transitioned access of the data to SBE for review. Clear Ballot also provided credentials to the two participating counties and SBE members allowing access to the audit databases.

Project Team and Staffing

The Maryland SBE Independent Automated Post-Election Audit Pilot Project consisted of a skilled and knowledgeable team. The chart below provides information about project team members:

Name	Title	Project Role	Contact
Linda H. Lamone	State Administrator of Elections	Project Sponsor	http://www.elections.maryland.gov
Nikki Charlson	State Deputy Administrator of Elections	SBE Project Oversight	nikki.charlson@maryland.gov
Natasha Walker	Project Manager of Election Management Systems	SBE Election System Project Manager	natash.walker@maryland.gov
Amanda LaForge	Project Manager	SBE Project Manger	
Larry Moore	Chief Executive Officer	CBG Sponsor	sales@clearballot.com
Bill Murphy	Director of Sales	CBG Project Oversight	bill.murphy@clearballot.com
Ana Quevedo	Customer Support Manager	CBG Project Manager	ana.quevedo@clearballot.com
Carolyne Kelley	Project Manager	CBG Assistant Project Manager	carolyne.kelley@clearballot.com
Tim Halvorsen	Chief Technology Officer	Chief Architect	info@clearballot.com
Chip Moore	Senior Engineer	Senior Developer	info@clearballot.com

The audit pilot project team members utilized standard project management methodologies to successfully complete the project. The project team was a matrixed organization with full support from functional managers and senior leadership. Effective communication, detailed planning, stakeholder involvement, project management tools, and organizational structure all played key roles in the project's success.

Project Deliverables (Planned vs. Actual)

The Post-Election Audit Project has been completed successfully. There were planned deliverables for each phase of this project as well as for the completed product. This section highlights the planned deliverables and compares them to actual deliverables as they occurred.

Requirements and Data Gathering

Planned Deliverable	Actual Deliverable	Summary
Precinct summary with group detail	EL30A report w/over & undervotes	Validation of data structure
April 26, 2016 Primary Election ballot PDF files	Primary ballot proofs-naming convention Party Code-Style number-card numbers-party abbreviation (Ex: 01-00008-01-REP or DEM)	CBG- parse the PDF data, finalized ClearAudit coding of the ballot definition files (BDF)
Precinct/ballot style matrix	Matrix for Montgomery & Carroll Counties	Validation of data structure. Map ballot styles to precincts
Clear Ballot customer survey	Customer survey for Montgomery & Carroll Counties	Initial planning of ClearAudit database
Samples of DS200 & DS850 ballot images	SBE uploaded samples of pilot election w/voted images (Ex:4568i.pdf)	CBG-to create comparison results files (CRF) for initial testing
Post-Election final unencrypted ballot images	EV, ED, AB, and provisional ballot images received Post-Election for April 26, 2016 Primary Election	SBE uploaded all final unencrypted ballot images and final precinct results files for pilot counties

Data Conversion (CRF Creation)

Planned Deliverable	Actual Deliverable	Summary
CBG-Create CRF files for sample DS200 & DS850 ballot images	CRF files were created for the sample files and a test election created in ClearAudit	Test ballot images were successfully tabulated.
CBG- set up audit environment	Configure ClearAudit Server, setup and connect system	The CRF files were imported into the test election for report verification
CBG- Create final CRF files	Generate Final Comparison VS, populate final VS tables, & package the final CRF CSV files	CBG created the Primary Election audit database for auditing the Montgomery & Carroll April 26, 2016 Primary Election files

Image Tabulation Testing

Planned Deliverable	Actual Deliverable	Summary
Tabulate ballot all ballot images for Maryland pilot counties	Tabulate all April 26, 2016 Primary Election ballot images for Montgomery & Carroll	All ballot images for Montgomery and Carroll County were successfully tabulated/adjudicated

Review (Analysis of data with SBE)

Planned Deliverable	Actual Deliverable	Summary
Import the CRF files into the April 26, 2016 Pilot Primary Election	Produce Comparison of Votes Reports for review and analysis by SBE & pilot counties	Comparison of Votes Reports were uploaded to ShareFile for SBE/pilot county ClearAudit analysis

Final Project Deliverables

Planned Deliverable	Actual Deliverable	Summary
MAEO Annual Meeting, Presentation to local board	Presentation conducted at MAEO Annual Meeting on June 20, 2016	SBE/CBG- Two 1 hour-sessions. Review of the audit process and display of Comparison of Results Reports, Q&A
Presentation to SBE & other interested parties	Presentation conducted at the SBE on June 30, 2016	SBE/CBG-Review of the audit process and display of Comparison of Results Reports, Q&A
Completed Document Retention Reference Package for SBE	A CD will be shipped to the SBE	Project documents and access to the two audit databases will be maintained for 5 years

In summary, all documented project deliverables have been met by the project team. All stakeholders have submitted their feedback and acknowledge that there are no deliverables which were missed or omitted for this project.

Transition to Analysis by SBE and Close-Out

Future projects can benefit from maintaining the ES&S ballot Cast Vote Record ID as part of the ClearAudit ballot ID (Ex:4568i.pdf). This will ensure cross reference between the two systems for vote adjudication verification purposes. Also, incorporating ExpressVote barcode export functionality will allow an independent system to audit voted ExpressVote ballots.

Project Schedule

The Maryland SBE Post-Election Audit Project schedule called for a project with initiation beginning on May 2, 2016 and project closeout ending on July 31, 2016. The chart below shows each phase of the project lifecycle, the planned schedule dates, and the actual completion dates of each phase.

Project Phase	Scheduled Start	Actual Completion	Comments
Initiation	May 2, 2016	May 20, 2016	Completed on time
Data Conversion	May 18, 2016	May 24, 2016	Completed on time
Tabulation of ballot Images	May 25, 2016	May 27, 2016	Completed on time
Review & Analyze Data	May 31, 2016	June 1, 2016	Completed on time
MAEO Presentation to Local Boards	June 20, 2016	June 20, 2016	Completed on time
Presentation to SBE	June 30, 2016	June 30, 2016	Completed on time
Project Closure	July 1, 2016	July 31, 2016	Completed on time

The Maryland audit project team successfully completed each phase on time which can be attributed to effective planning and communication as well as sponsor and executive level support of this important initiative. Throughout the project there was a strong sense of cooperation across the organization as the importance of this project was stressed and its benefits were realized.

The assigned staff was adequate to complete all work packages in the planned timeframes. The tabulation phase required schedule adjustments for the tabulation of unreadable images. The Clear Ballot project team was able to reallocate its resources and complete the work packages within the planned timeframe.

Project Costs

The budgeted cost for the Maryland SBE Post-Election Audit Project was set at $75,000.

This price covers all services and deliverables referenced in Exhibit A - Independent Automated Post-Election Audit Method – Pilot Program – Scope of Work.

Recommendations

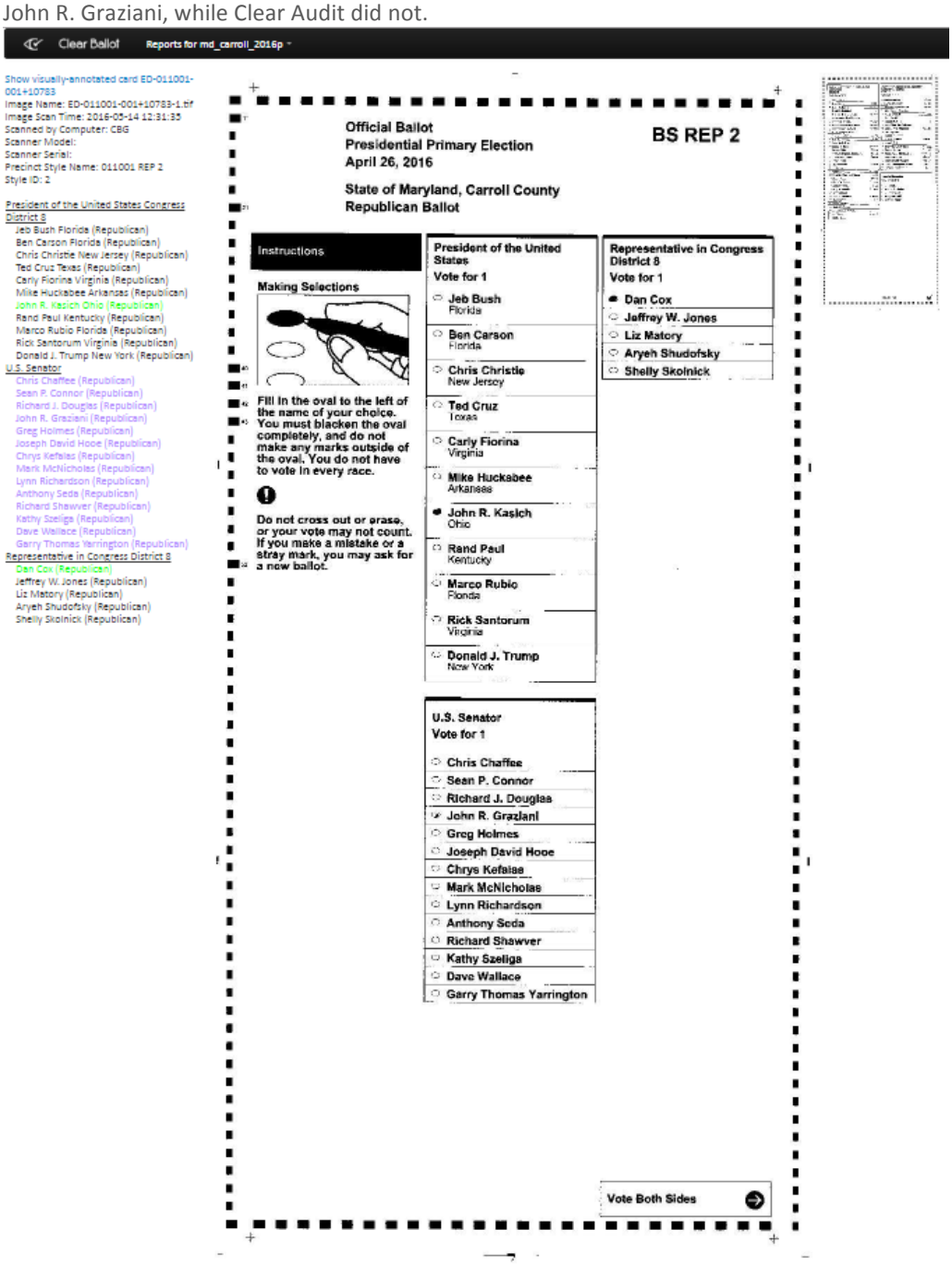
The audit project was an example of a carefully planned and successfully executed project. However, Clear Ballot would like to propose the following recommendations for future audits using ClearAudit:

Clear Ballot Recommendations

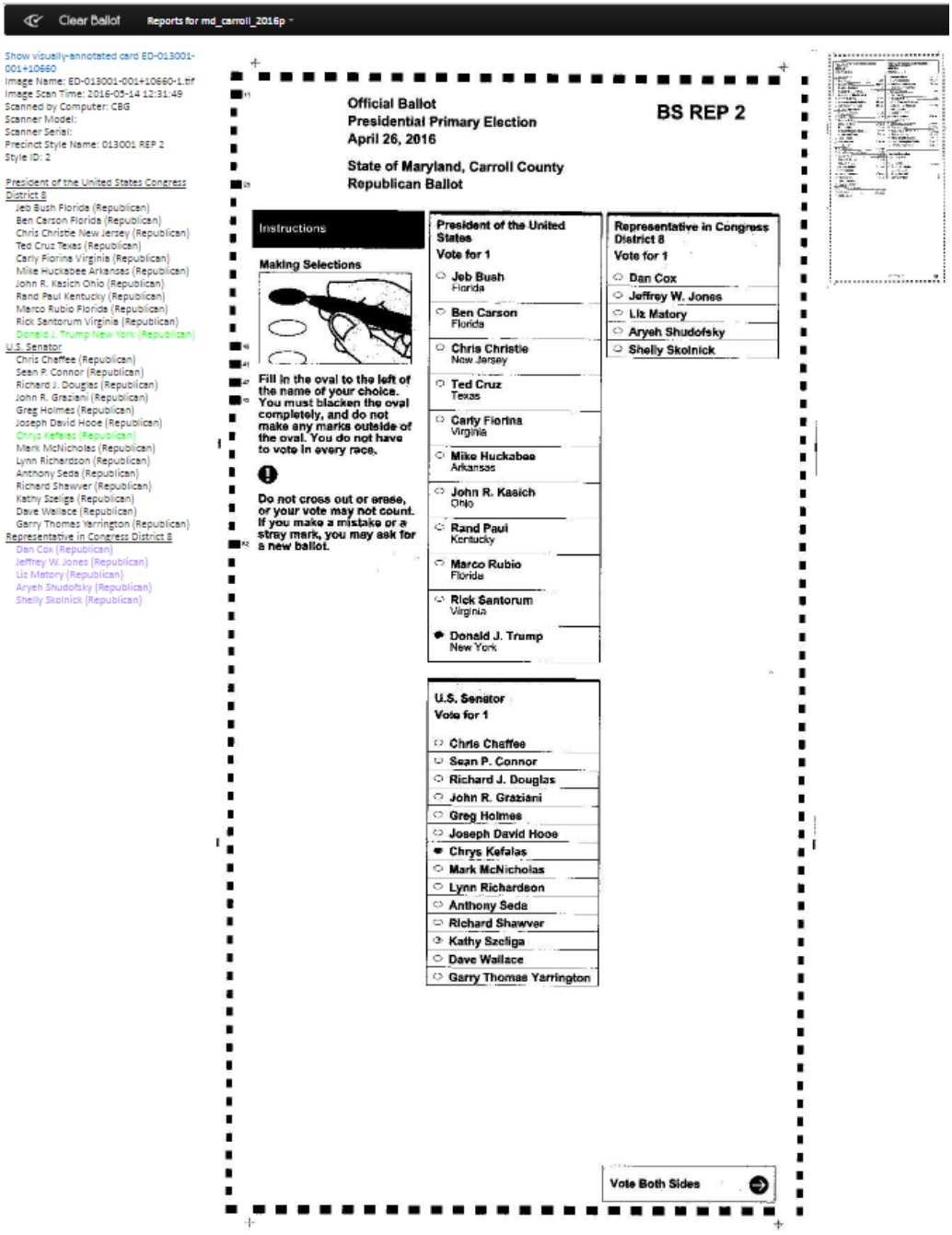
- Provide Ballot PDF files in readable format to Clear Ballot immediately after the logic and accuracy (L&A) test and prior to ballot transmittal to UOCAVA voters (preferably 45 days prior to Election Day)
- Provide L&A Cast Vote Records and EL30A report to Clear Ballot for verification of testing of the ClearAudit system
- Clear Ballot continues to host tabulation system in our secure data center
- Each County provides voted ballot images on a physical hard drive to be delivered to Clear Ballot via USPS or other certified mail service
- A scheduled submittal of voted ballot images as counties complete their canvass
- Request ExpressVote barcode information from the primary voting system

Appendix B

On the ballot image below, the primary voting system counted a vote for U.S. Senate candidate John R. Graziani, while Clear Audit did not.



On the ballot image below, the primary voting system identified an overvote in the U.S. Senate contest (a vote for Kathy Szeliga and a vote for Chris Kefalas), while ClearAudit counted a vote for Chris Kafalas.



Appendix C

Fixed Percentage Audit Tally Sheet (Carroll County Pilot)						
Party: Republican		Precinct:		Batch:		
Team Members:						
Contest/Candidate						
	CVR #	CVR #	CVR #	CVR #	CVR #	Total
President						
J. Bush						
B. Carson						
C. Christie						
T. Cruz						
C. Fiorina						
M. Huckabee						
J. Kasich						
R. Paul						
M. Rubio						
R. Santorum						
D. Trump						
Undervote						
Overvote						
Senate						
C. Chaffee						
S. Connor						
R. Douglas						
J. Graziani						
G. Holmes						
J. Hooe						
C. Kefalas						
M. McNicholas						
L. Richardson						
A. Seda						
R. Shawver						
K. Szeliga						
D. Wallace						
G. Yarrington						
Undervote						
Overvote						
House (CD 1)						
J. Goff						
A. Harris						
S. Jackson						
M. Smigiel						
Undervote						
Overvote						
House (CD 8)						
D. Cox						
J. Jones						
L. Matory						
A. Shudofsky						
S. Skolnick						
Undervote						
Overvote						

Fixed Percentage Audit Batch Tally Sheet (Carroll County Pilot)						
Party: Republican			Precinct:		Batch:	
Team Members:						
Contest/Candidate						
	Ballots # 1-5	Ballots # 5-10	Ballots # 11-15	Ballots # 16-20	Ballots # 21-25	Total
President						
J. Bush						
B. Carson						
C. Christie						
T. Cruz						
C. Fiorina						
M. Huckabee						
J. Kasich						
R. Paul						
M. Rubio						
R. Santorum						
D. Trump						
Undervote						
Overvote						
Senate						
C. Chaffee						
S. Connor						
R. Douglas						
J. Graziani						
G. Holmes						
J. Hooe						
C. Kefalas						
M. McNicholas						
L. Richardson						
A. Seda						
R. Shawver						
K. Szeliga						
D. Wallace						
G. Yarrington						
Undervote						
Overvote						
House (CD 1)						
J. Goff						
A. Harris						
S. Jackson						
M. Smigiel						
Undervote						
Overvote						
House (CD 8)						
D. Cox						
J. Jones						
L. Matory						
A. Shudofsky						
S. Skolnick						
Undervote						
Overvote						

Fixed Percentage Audit Batch Tally Sheet (Carroll County Pilot)						
Party: Republican			Precinct:			
Team Members:						
Contest/Candidate						
	Batch # 1	Batch # 2	Batch # 3	Batch # 4	Batch # 5	Total
President						
J. Bush						
B. Carson						
C. Christie						
T. Cruz						
C. Fiorina						
M. Huckabee						
J. Kasich						
R. Paul						
M. Rubio						
R. Santorum						
D. Trump						
Undervote						
Overvote						
Senate						
C. Chaffee						
S. Connor						
R. Douglas						
J. Graziani						
G. Holmes						
J. Hooe						
C. Kefalas						
M. McNicholas						
L. Richardson						
A. Seda						
R. Shawver						
K. Szeliga						
D. Wallace						
G. Yarrington						
Undervote						
Overvote						
House (CD 1)						
J. Goff						
A. Harris						
S. Jackson						
M. Smigiel						
Undervote						
Overvote						
House (CD 8)						
D. Cox						
J. Jones						
L. Matory						
A. Shudofsky						
S. Skolnick						
Undervote						
Overvote						

Risk Limiting Ballot-Level Audit Tally Sheet (Carroll County Pilot)					
Party: Republican					
Team Members:					
Contest/Candidate					
	CVR #/D-P	CVR #/D-P	CVR #/D-P	CVR #/D-P	CVR #/D-P
President					
J. Bush					
B. Carson					
C. Christie					
T. Cruz					
C. Fiorina					
M. Huckabee					
J. Kasich					
R. Paul					
M. Rubio					
R. Santorum					
D. Trump					
No Vote					
Senate					
C. Chaffee					
S. Connor					
R. Douglas					
J. Graziani					
G. Holmes					
J. Hope					
C. Kefalas					
M. McNicholas					
L. Richardson					
A. Seda					
R. Shawver					
K. Szeliga					
D. Wallace					
G. Yarrington					
No Vote					
House (CD 1)					
J. Goff					
A. Harris					
S. Jackson					
M. Smigiel					
No Vote					
House (CD 8)					
D. Cox					
J. Jones					
L. Matory					
A. Shudofsky					
S. Skolnick					
No Vote					
CVR Verification (please initial)					

Appendix D

2016 Primary Election Carroll County

Ballot Level Audit Applying Risk Limiting Principles - Randomly Selected Ballots

Cast Vote Record Number	Precinct	Cast Vote Record Number	Precinct	Cast Vote Record Number	Precinct	Cast Vote Record Number	Precinct
5708	001-001	12520	004-003	19652	005-004	27360	014-002
6021	001-001	12555	004-003	19848	005-004	27442	014-002
6153	001-001	12678	004-003	19916	005-004	27825	014-001
6267	001-001	12785	004-003	19933	005-004	27894	014-001
6305	001-001	12791	004-003	20018	005-004	27924	014-001
6330	001-001	12959	004-003	20084	005-004	28400	014-001
6461	001-001	13108	004-003	20403	005-004	28462	014-001
6551	001-001	13160	004-003	20462	005-004	28554	014-001
6611	001-001	13540	004-003	20498	005-004	28560	014-001
6652	001-001	13600	004-003	20519	005-004	29003	013-001
6826	001-001	13744	004-002	20693	005-004	29088	013-001
6854	001-001	13905	004-002	20731	005-004	29101	013-001
6928	001-001	14062	004-002	21007	005-004	29112	013-001
6981	001-001	14130	004-002	21047	005-005	29325	013-001
6997	001-001	14318	004-002	21077	005-005	29372	013-001
7075	001-001	14910	005-001	21173	005-005	29454	013-001
7306	001-001	14923	005-001	21288	005-005	29537	013-001
7354	001-001	15021	005-001	21330	005-005	29599	013-001
8068	002-001	15202	005-001	21607	005-005	29670	013-001
8166	002-002	15692	005-002	21710	005-005	29734	013-001
8218	002-002	15708	005-002	21981	005-006	29788	013-001
8363	002-002	16015	005-002	22173	006-001	29947	013-001
8474	002-002	16064	005-002	22806	006-001	30014	013-001
8704	002-002	16339	005-002	22890	006-001	30198	013-001
8808	003-001	16580	005-002	22950	006-001	30450	013-001
8842	003-001	16599	005-002	22994	006-001	30502	013-001
9195	003-001	16929	005-002	23064	006-001	30652	013-001
9274	003-001	17195	005-002	23176	006-001	30703	013-001
9339	003-001	17233	005-002	23324	006-001	30770	013-001
9344	003-001	17276	005-002	23525	006-001	30985	013-001
9409	003-001	17470	005-002	23701	006-001	31017	013-001
9806	003-001	17472	005-002	23846	006-001	31171	013-001
9853	003-001	17580	005-003	24062	006-002	31481	012-001
9898	003-001	17936	005-003	24933	006-002	31638	011-001
10171	004-001	17991	005-003	25142	006-002	31674	011-001
10252	004-001	18130	005-003	25162	006-002	31729	011-001
10864	004-001	18636	005-004	25199	006-002	31809	011-001
11207	004-001	18767	005-004	25343	006-002	32325	011-001
11363	004-001	18795	005-004	26253	014-002	32371	011-001
11364	004-001	19127	005-004	26381	014-002	32789	010-001
11646	004-001	19196	005-004	26446	014-002	32812	010-001
11690	004-001	19262	005-004	26485	014-002	32900	009-002
12170	004-003	19536	005-004	27255	014-002	32978	009-002

2016 Primary Election

Carroll County

Ballot Level Audit Applying Risk Limiting Principles - Randomly Selected Ballots

Cast Vote Record Number	Precinct	Cast Vote Record Number	Precinct
33038	009-002	39909	007-007
33131	009-002	40281	007-007
33155	009-002	40332	007-007
33286	009-002	40496	007-007
33556	009-001	40614	007-006
34063	009-001	40734	007-006
34078	009-001	40970	007-006
34526	009-001	41017	007-006
34656	009-001	41035	007-006
34861	008-003	41226	007-006
34955	008-003	41366	007-005
35058	008-003	41457	007-005
35119	008-003	41730	007-004
35178	008-003	41804	007-004
35270	008-003	41828	007-004
35377	008-003	41991	007-004
35441	008-003	42055	007-004
35744	008-002	42174	007-004
35747	008-002	42208	007-004
36029	008-002	42312	007-004
36035	008-002	42371	007-004
36137	008-002	43329	007-004
36286	008-002	43654	007-003
36442	008-002	43693	007-003
36461	008-002	44036	007-003
36564	008-002	44171	007-002
36575	008-002	44297	007-002
36799	008-001	44347	007-002
36811	008-001	44608	007-002
36907	008-001	44984	007-002
37233	008-001	45083	007-001
37253	008-001	45338	007-001
37425	008-001		
38212	008-001		
38660	007-008		
38706	007-008		
38719	007-008		
38756	007-008		
38910	007-008		
38937	007-008		
39046	007-007		
39330	007-007		
39338	007-007		

2016 Primary Election

Montgomery County

Ballot Level Audit Applying Risk Limiting Principles - Randomly Selected Ballots

Cast Vote Record Number	Precinct
44279	001-007
44782	002-001
44801	002-001
47281	002-003
55081	003-001
56845	004-002
57711	004-003
58989	004-005
59284	004-005
60934	004-009
61504	004-007
62765	004-008
63075	004-010
67220	004-013
70476	004-018
70543	004-018
73147	010-001
73545	004-020
73801	004-020
76646	004-032
76659	004-032
78130	005-013
79089	005-006
79956	005-001
82135	005-006
83626	005-016
84250	005-008
85913	005-017
86193	005-017
87190	005-018
87516	005-005
90456	005-021
91752	005-012
92938	007-004
93108	007-004
93445	005-023
101774	006-014
102120	007-009
104524	006-005
108905	007-011
109444	007-012
109604	007-012
113169	006-007
115658	007-023
118644	007-024
123289	008-005
125010	008-007
130187	013-039
131233	013-039
133329	013-018
133418	013-018
135555	013-013
137212	013-003
138253	013-011
141184	013-015
141317	013-015
145389	013-021
146050	013-001
147627	013-035
149469	013-031
150942	012-005
154441	013-029
159623	009-002
160616	011-000
162230	010-013
165936	009-007
168267	009-035
173391	009-027
177570	009-018
177863	010-006
182120	009-013
182647	010-004
185664	009-029
185993	009-029
188341	013-069
189240	013-051
192415	013-042
195649	008-011
197343	013-068
201627	013-043
208009	007-019
209016	013-056

Appendix E

Cast Vote Record: 48,087

Poll Place: **NCS, Inc. Building**
Precinct: **002-002**
Ballot Style: **Rep Ballot Style 1 [Sheet Number 1]**
Party: **Republican**
Serial Number: **0173000010**
Machine Serial: **8515070173**
Blank Ballot: **NO**

Contests:

PRESIDENT 1 (64)
Vote For: 1

Mitt Romney (89)	**Counted**

U.S. SENATOR (66)
Vote For: 1

David Jones (97)	**Counted**

U.S. CONGRESS 1 (68)
Vote For: 1

Undervoted	**Undervoted**

REP DELEGATES 1 (70)
Vote For: 3

Victoria Seitzinger (119)	**Counted**
Derrick Smith (121)	**Counted**
Richard Sossi (122)	**Counted**

REP ALTERNATES 1 (72)
Vote For: 3

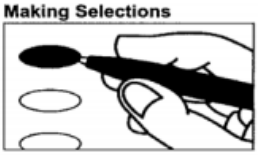
Undervoted	**Undervoted**
Undervoted	**Undervoted**
Undervoted	**Undervoted**

BS REP 1

Official Ballot
Queen Anne's County 2015 Mock Election
State of Maryland, Queen Anne's County
October 22, 2015
Republican Ballot

Instructions

Making Selections



Fill in the oval to the left of the name of your choice. You must blacken the oval completely, and do not make any marks outside of the oval. You do not have to vote in every race.

Do not cross out or erase, or your vote may not count. If you make a mistake or a stray mark, you may ask for a new ballot.

President of the United States
Vote for 1

- ○ Newt Gingrich — Virginia
- ○ Jon Huntsman — Utah
- ○ Fred Karger — California
- ○ Ron Paul — Texas
- ○ Rick Perry — Texas
- ○ Buddy Roemer — Louisiana
- ● Mitt Romney — Massachusetts
- ○ Rick Santorum — Pennsylvania

U.S. Senator
Vote for 1

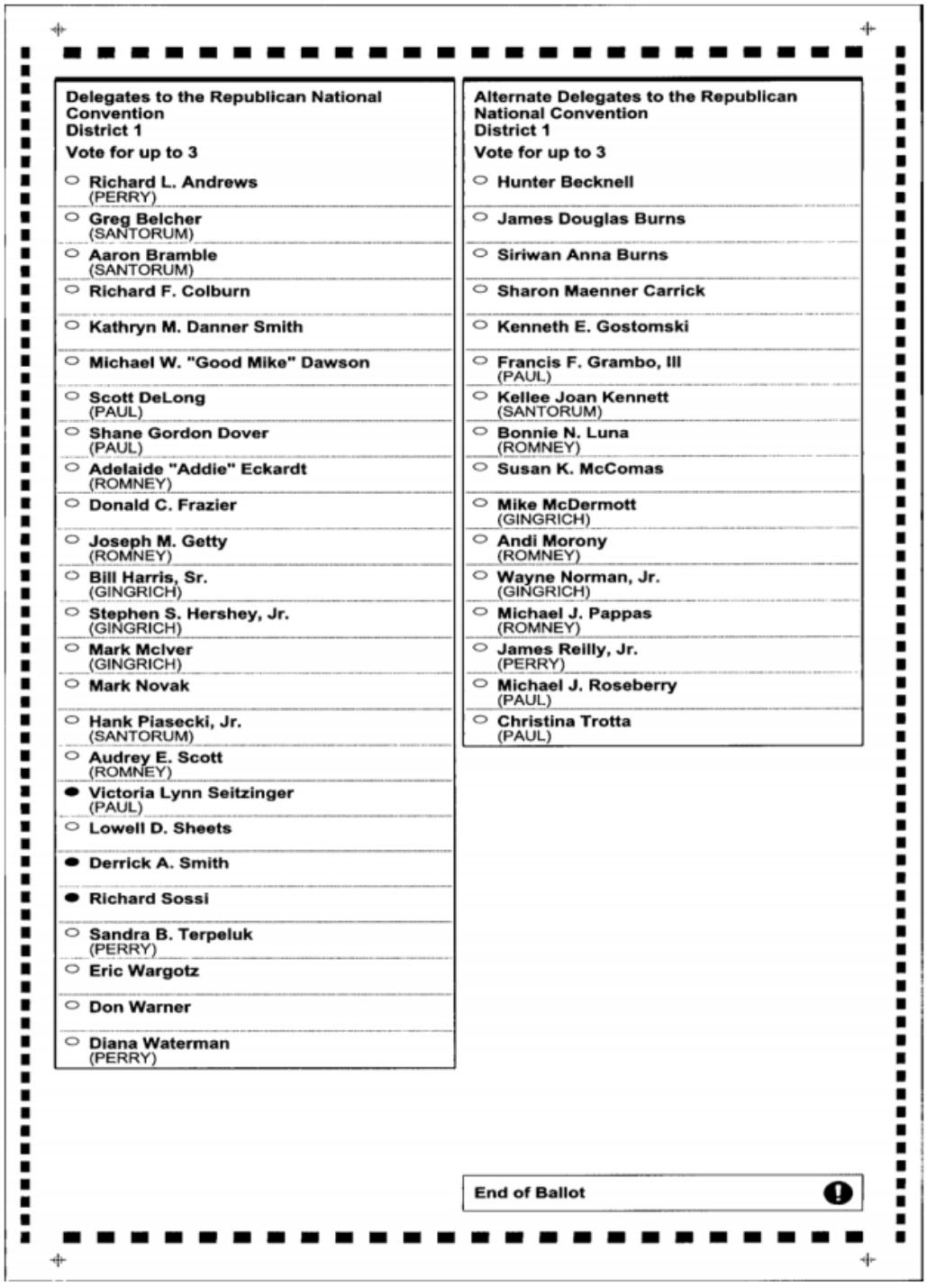
- ○ Joseph Alexander
- ○ Dan Bongino
- ○ Robert "BRO" Broadus, Jr.
- ○ William Thomas Capps, Jr.
- ○ Richard J. Douglas
- ○ Rick Hoover
- ● David Jones, II
- ○ John B. Kimble
- ○ Brian Charles Vaeth
- ○ Corrogan R. Vaughn

Representative in Congress District 1
Vote for 1

- ○ Andy Harris — Unopposed

Vote Both Sides

Typ:01 Seq:0001 Spl:01 Ballot Style #1



Delegates to the Republican National Convention
District 1
Vote for up to 3

- ○ Richard L. Andrews (PERRY)
- ○ Greg Belcher (SANTORUM)
- ○ Aaron Bramble (SANTORUM)
- ○ Richard F. Colburn
- ○ Kathryn M. Danner Smith
- ○ Michael W. "Good Mike" Dawson
- ○ Scott DeLong (PAUL)
- ○ Shane Gordon Dover (PAUL)
- ○ Adelaide "Addie" Eckardt (ROMNEY)
- ○ Donald C. Frazier
- ○ Joseph M. Getty (ROMNEY)
- ○ Bill Harris, Sr. (GINGRICH)
- ○ Stephen S. Hershey, Jr. (GINGRICH)
- ○ Mark McIver (GINGRICH)
- ○ Mark Novak
- ○ Hank Piasecki, Jr. (SANTORUM)
- ○ Audrey E. Scott (ROMNEY)
- ● Victoria Lynn Seitzinger (PAUL)
- ○ Lowell D. Sheets
- ● Derrick A. Smith
- ● Richard Sossi
- ○ Sandra B. Terpeluk (PERRY)
- ○ Eric Wargotz
- ○ Don Warner
- ○ Diana Waterman (PERRY)

Alternate Delegates to the Republican National Convention
District 1
Vote for up to 3

- ○ Hunter Becknell
- ○ James Douglas Burns
- ○ Siriwan Anna Burns
- ○ Sharon Maenner Carrick
- ○ Kenneth E. Gostomski
- ○ Francis F. Grambo, III (PAUL)
- ○ Kellee Joan Kennett (SANTORUM)
- ○ Bonnie N. Luna (ROMNEY)
- ○ Susan K. McComas
- ○ Mike McDermott (GINGRICH)
- ○ Andi Morony (ROMNEY)
- ○ Wayne Norman, Jr. (GINGRICH)
- ○ Michael J. Pappas (ROMNEY)
- ○ James Reilly, Jr. (PERRY)
- ○ Michael J. Roseberry (PAUL)
- ○ Christina Trotta (PAUL)

End of Ballot

Appendix F

Carroll County Fixed Percentage Audit Precinct Selection Chart

District	Precinct	Votes Cast	Cumulative votes	Lower bound	Upper bound	roll 6 dice
1	1	1336	1336	0	0.050484	
2	1	409	1745	0.050485	0.065939	
2	2	445	2190	0.06594	0.082754	
3	1	929	3119	0.082755	0.117858	
4	1	1360	4479	0.117859	0.169249	
4	2	602	5081	0.16925	0.191997	
4	3	1148	6229	0.191998	0.235376	
5	1	654	6883	0.235377	0.260089	
5	2	1171	8054	0.26009	0.304338	
5	3	595	8649	0.304339	0.326821	
5	4	1549	10198	0.326822	0.385354	
5	5	538	10736	0.385355	0.405683	
5	6	136	10872	0.405684	0.410822	
6	1	1315	12187	0.410823	0.460512	
6	2	1090	13277	0.460513	0.5017	
7	1	278	13555	0.501701	0.512205	
7	2	634	14189	0.512206	0.536162	
7	3	412	14601	0.536163	0.551731	
7	4	1069	15670	0.551732	0.592125	
7	5	229	15899	0.592126	0.600778	
7	6	483	16382	0.600779	0.61903	
7	7	928	17310	0.619031	0.654096	
7	8	430	17740	0.654097	0.670345	
8	1	1086	18826	0.670346	0.711381	
8	2	793	19619	0.711382	0.741347	
8	3	595	20214	0.741348	0.76383	
9	1	901	21115	0.763831	0.797876	
9	2	400	21515	0.797877	0.812991	
10	1	259	21774	0.812992	0.822778	
11	1	628	22402	0.822779	0.846508	
12	1	220	22622	0.846509	0.854822	
13	1	1741	24363	0.854823	0.920609	
14	1	694	25057	0.92061	0.946833	
14	2	1240	26297	0.946834	0.99369	
14	3	167	26464	0.993691	0.999999	
	35					

Montgomery County Fixed Percentage Audit Precinct Selection Chart

Precinct	Democratic votes	Cumulative Democratic Votes	Cumulative Percent of Democratic Votes	Lower Bound of Dice Roll Range	Upper Bound of Dice roll Range	roll 7 dice to select each precinct
001-001	258	258	0.001962933	0.0000000	0.0019629	
001-002	357	615	0.004679083	0.0019630	0.0046791	
001-003	660	1275	0.009700539	0.0046792	0.0097005	
001-004	368	1643	0.01250038	0.0097006	0.0125004	
001-005	468	2111	0.016061049	0.0125005	0.0160610	
001-006	262	2373	0.018054414	0.0160611	0.0180544	
001-007	54	2427	0.018465261	0.0180545	0.0184653	
002-001	623	3050	0.02320521	0.0184654	0.0232052	
002-002	617	3667	0.02789951	0.0232053	0.0278995	
002-003	636	4303	0.032738367	0.0278996	0.0327384	
002-004	657	4960	0.037736997	0.0327385	0.0377370	
002-005	584	5544	0.042180225	0.0377371	0.0421802	
002-006	570	6114	0.046516936	0.0421803	0.0465169	
002-007	5	6119	0.046554977	0.0465170	0.0465550	
002-008	450	6569	0.049978697	0.0465551	0.0499787	
002-009	55	6624	0.050397151	0.0499788	0.0503972	
002-010	234	6858	0.052177486	0.0503973	0.0521775	
002-011	542	7400	0.056301166	0.0521776	0.0563012	
003-001	417	7817	0.059473812	0.0563013	0.0594738	
003-002	366	8183	0.062258438	0.0594739	0.0622584	
004-001	730	8913	0.067812471	0.0622585	0.0678125	
004-002	645	9558	0.072719803	0.0678126	0.0727198	
004-003	927	10485	0.079772665	0.0727199	0.0797727	
004-004	532	11017	0.083820262	0.0797728	0.0838203	
004-005	496	11513	0.087593962	0.0838204	0.0875940	
004-006	444	11957	0.090972032	0.0875941	0.0909720	
004-007	518	12475	0.094913114	0.0909721	0.0949131	
004-008	1052	13527	0.102917009	0.0949132	0.1029170	
004-009	386	13913	0.1058538	0.1029171	0.1058538	
004-010	586	14499	0.110312243	0.1058539	0.1103122	
004-011	86	14585	0.110966554	0.1103123	0.1109666	
004-012	761	15346	0.116756444	0.1109667	0.1167564	
004-013	686	16032	0.121975714	0.1167565	0.1219757	
004-014	702	16734	0.127316717	0.1219758	0.1273167	
004-015	263	16997	0.129317691	0.1273168	0.1293177	
004-016	775	17772	0.135214097	0.1293178	0.1352141	
004-017	612	18384	0.139870355	0.1352142	0.1398704	
004-018	728	19112	0.145409173	0.1398705	0.1454092	
004-019	301	19413	0.14769926	0.1454093	0.1476993	
004-020	734	20147	0.153283727	0.1476994	0.1532837	
004-021	679	20826	0.15844974	0.1532838	0.1584497	
004-023	37	20863	0.158731246	0.1584498	0.1587312	
004-024	464	21327	0.162261481	0.1587313	0.1622615	