Report of the
Joint Legislative Audit and Review Commission
To the Governor and
The General Assembly of Virginia

Review of Post-election Audits of Voting Equipment

SENATE DOCUMENT NO. 9
2010

In Brief

Senate Joint Resolution 328 (2009) directed JLARC staff to study post-election audits of voting equipment. A post-election audit is typically conducted to test the accuracy of voting equipment. The test consists of comparing the tally of election results produced by the voting equipment on election day to a subsequent tally conducted during an audit. Various statistical strategies are used to draw samples to include in the audit, and various counting methods can be used to conduct the audit.

JLARC staff worked with the State Board of Elections and four localities to conduct a pilot post-election audit project. The pilot project found a 0.21 percent difference between election day and audit results. This difference would change the outcome only in the closest of elections.

Post-election audits can provide benefits, such as increasing election transparency and providing insight into voting equipment security, accuracy, and reliability. A locality would spend, on average, about five hours on the audit process. There are several key implementation considerations, including the diversity of voting equipment used in Virginia, which would be relevant when deciding whether to require an ongoing, large-scale post-election audit program.

JLARC Staff for This Report

Bob Rotz, Division Chief
Justin Brown, Project Leader
Stefanie Papps
Greg Rest

This report is available on the JLARC website at http://jlarc.virginia.gov

COMMONWEALTH of VIRGINIA

Joint Legislative Audit and Review Commission

Philip A. Leone
Director

Suite 1100, General Assembly Building, Capitol Square
Richmond, Virginia 23219

(804) 786-1258

July 19, 2010

The Honorable Charles J. Colgan
Chairman
Joint Legislative Audit and Review Commission
General Assembly Building
Richmond, VA 23219

Dear Senator Colgan:

Senate Joint Resolution 328 from the 2009 General Assembly directed us to study post-election audits of voting equipment. Items specifically noted in the resolution for us to address included estimating the time and cost of conducting post-election audits, as well as incorporating the results of pilot post-election audits conducted in Virginia. Findings of the study were presented to the Commission on June 14, 2010.

On behalf of the Commission staff, I would like to thank the State Board of Elections staff for their assistance during this study. I would also like to thank the general registrars, electoral boards, and clerks of the circuit court in the City of Charlottesville, and Page, Chesterfield, and Fairfax counties. Finally, I would like to thank those from voters' rights organizations and academia who helped our staff during the study.

Sincerely,

Philip A. Leone
Director

PAL/jcb

Table of Contents

Appendixes

JLARC Report Summary:

Review of Post-election Audits of Voting Equipment

Key Findings

- Twenty-three states currently require post-election audits. These states primarily use a fixed-percentage audit strategy and rarely find substantial discrepancies between election day and audit results during their audits. (Chapter 3)
- Virginia's post-election audit pilot project revealed a 0.21 percent difference between election day and audit results. This difference would change the outcome only in the closest of elections. (Chapter 4)
- Post-election audits can provide benefits, such as increasing election transparency and providing insight into voting equipment security, accuracy, and reliability. A locality would spend, on average, about five hours on the audit process. (Chapters 5 and 6)
- There are several key implementation considerations relevant when deciding whether to require an ongoing, large-scale post-election audit program. These include Virginia's diversity of voting equipment and the fact that certain benefits of audits can be achieved by conducting additional pilot audits or giving localities the option to conduct audits if they wish. (Chapter 6)

Post-election Audits

A post-election audit is typically conducted to test the accuracy of voting equipment. The test consists of comparing the tally of election results produced by the voting equipment on election day to a subsequent tally conducted during an audit. Various statistical strategies are used to draw different samples to include in the audit, and various counting methods can be used to conduct the audit.

Senate Joint Resolution 328 (2009) directed JLARC staff to study post-election audits of voting equipment. Virginia localities currently use two types of voting equipment: direct recording equipment (DRE) and optical scan (OS) machines. Prior to the passage of SJR 328, there were several key legislative efforts to address concerns about the voting equipment currently used in Virginia. Chief among these was in 2007, when the General Assembly prohibited future purchases of DRE machines. Additionally, legislation was introduced during several General Assemblies, but not enacted, that would have required post-election audits of voting equipment. In 2008, the *Code of Virginia* was amended, however, to allow for pilot post-election audits of OS machine paper ballots. DREs used in Virginia do not have paper ballots, which was part of the concern leading to the prohibition noted above.

TWENTY-SEVEN STATES DO NOT REQUIRE POST-ELECTION AUDITS, WHILE 23 STATES DO

Twenty-seven states including Virginia do not require post-election audits, while the other 23 states do require some form of audit. North Carolina, West Virginia, and the District of Columbia do

conduct audits while Maryland does not. States that do require post-election audits conduct them to achieve various purposes, including to enhance election transparency and increase voter confidence. Most states report their audits are an effective use of resources.

Most states that conduct audits use a fixed-percentage (FP) strategy, which consists of auditing a consistent sample size after each election. Most states use either a hand-to-eye count (HTEC) or a combination of that method and a machine-assisted (MA) method. The vast majority of post-election audits conducted by other states do not find discrepancies that change the outcome of the election. When discrepancies are found, they tend to be relatively small and attributable to factors such as a voter incorrectly completing a ballot. Still, proponents of post-election audits advocate that audits are an important way to check the security, reliability, and accuracy of voting equipment used in elections.

VIRGINIA'S PILOT PROJECT YIELDED SEVERAL LESSONS

JLARC staff worked with the State Board of Elections, the Virginia Electoral Board Association, and the Voter Registrars' Association of Virginia to conduct a pilot post-election audit project. The City of Charlottesville and Page, Chesterfield, and Fairfax Counties volunteered to participate in the pilot project. The audits were conducted in February and March 2010, using variations of the HTEC or MA audit method (see photographs below).

The audits resulted in several lessons learned about voting equipment and post-election audits. Perhaps the most important lesson learned was that the difference between the election day totals and

Examples of HTEC and MA Audit Methods Used in Chesterfield and Fairfax Counties

Ballots Sorted on Tables Using Hand-to-eye Count Method in Chesterfield County

Ballots Tabulated Using Machine-assisted Counting Method in Fairfax County

Source: JLARC staff photos taken at the Chesterfield County and Fairfax County post-election audits on March 10 and 15, 2010.

audit totals was, collectively, 0.21 percent (see table). This suggests that only in the closest of elections would the difference have affected the election outcome. It should be noted that Virginia law allows defeated candidates to appeal for a recount when the apparent margin of victory is at or below one percent.

Pilot Project: Differences Between Election Day and Audit Totals

Locality	Optical Scan Machine Audited	% Difference Between Election Day and Audit Totals
Page County	Optech IIIPE	0.33%
City of Charlottesville	eScan	0.00
Chesterfield County	M-100	0.00
Fairfax County	Accuvote	0.30
	Project Total	**0.21%**

Source: JLARC staff analysis of results of Virginia post-election audit pilot project.

SBE and localities may want to further assess the technical and logistical feasibility of reducing the instances in which incorrectly completed ballots are not tabulated.

Other lessons learned were that the OS machines audited could read many, though not all, ballots that were not properly completed by voters. Overall, the machines were fairly adept at tabulating these votes, but there were a few instances in which a human could read the vote on an incorrectly completed ballot but the machine could not. SBE and localities may want to further assess the technical and logistical feasibility of reducing the instances in which such ballots are not tabulated.

BENEFITS AND COSTS OF POST-ELECTION AUDITS SHOULD BE ASSESSED IN CONTEXT OF KEY IMPLEMENTATION CONSIDERATIONS

The potential benefits of post-election audits will vary depending on whether the FP or the adjustable-percentage (AP) statistical strategy is used (see figure, next page). The AP strategy, which utilizes larger sample sizes as the margin of victory narrows, would better accomplish validating the election outcome when compared to the FP strategy while the FP strategy would be superior in enhancing election transparency. checking the security, accuracy, and reliability of voting equipment, and identifying lessons learned.

The costs of the audits would also depend on the statistical strategy and audit methods used. For example, an FP audit of one-percent of precincts in Virginia would take a locality, on average, about 5.5 hours to complete. In total, localities could spend about $145,000 to conduct a one-percent FP audit. The vast majority of these expenditures would be fees paid to voting equipment vendors to prepare the voting machines for audit. Requiring the AP strategy would in most cases cost less and involve fewer localities.

Potential Benefits and Costs if Virginia Were to Require Post-election Audits

Audit Strategy	Potential Benefits				Potential Costs	
	(1) Election Transparency	*(2) Security, Accuracy, Reliability*	*(3) Lessons Learned*	*(4) Validate Election Outcome*	*Time*	*$*
1% Fixed - Percentage	●	●	●	◑	5.5 hours / locality	$145,267
Adjustable - Percentage[a]	◑	◑	◑	●	Range of 4.8 hours / locality[b] to same as full recount	Range of $15,822[b] to same as full recount

Legend for Scale of Potential Benefit ● High ◑ Medium ○ Low

[a] Assumes a margin of victory that is the average of a sample of races in Virginia since 2001, which is 13.7 percent.
[b] Would involve 11 localities with the margin of victory noted above.

Source: JLARC staff analysis.

However, in close elections the AP strategy's time and expenditures would be close to that of a full recount.

Finally, the above benefits and costs need to be assessed in the context of several important implementation considerations that are specific to Virginia. Among these is the prevalence of DREs used by localities, which do not have a paper trail, and therefore can only be audited by analyzing the machine's memory cards. Some computer scientists indicate that analyzing these memory cards has limited usefulness because the process, unlike an audit using a paper ballot, is not an independent check. Another consideration is that some of the benefits of post-election audits can likely be achieved in ways other than requiring an ongoing, large-scale audit program. These other ways could include continuing to conduct pilot audits under the existing statute, or amending the *Code of Virginia* to give localities permission to conduct them if they wish.

Chapter 1

Electoral Environment and Background

In Summary

Virginia's localities currently use either direct recording equipment (DRE) or optical scan machines to tabulate votes during elections. The majority of localities use a mix of both types of machines. As a way to check whether these machines tabulate votes properly during an election, some other states conduct post-election audits. Virginia, however, currently does not require or conduct these audits. Concern about both types of voting equipment led to several legislative initiatives that relate to voting equipment and post-election audits. In 2007, the General Assembly amended the *Code of Virginia* to prohibit localities from purchasing any new DREs. Additionally, legislation was introduced on several occasions that would have required post-election audits of voting equipment. This legislation was not enacted; however, in 2008 *the Code* was amended to allow for pilot post-election audits.

Post-election Audits

A post-election audit is typically conducted to test the accuracy of voting equipment. The test consists of comparing the tally of election results produced by the voting equipment on election day to a subsequent tally conducted during an audit. Various statistical strategies are used to draw different samples to include in the audit, and there are various counting methods that can be used to conduct the audit.

Senate Joint Resolution 328 from the 2009 General Assembly directs the Joint Legislative Audit and Review Commission (JLARC) staff to study post-election audits of voting equipment (Appendix A). The resolution identifies six items to be addressed during the study, which primarily involve collecting information about the time, cost, and outcomes of various post-election audit strategies and methods. Currently, Virginia does not require post-election audits of voting equipment.

KEY LEGISLATIVE INITIATIVES PRECEDING JLARC STUDY

The study resolution was preceded by several relevant legislative initiatives. In particular, the 2004 General Assembly passed House Joint Resolution 174, which established a joint subcommittee to study the certification process for voting equipment and the performance and proper deployment of voting equipment. The joint subcommittee met several times from mid-2005 to early 2006 and concluded with a final report. The final report addresses two key factors relevant to this JLARC study.

The first factor discussed in the report of the joint subcommittee was the variety of—and somewhat conflicting—perspectives on the reliability and usability of the electronic voting equipment being used by Virginia localities. For example,

- A professor from the Carnegie Mellon University School of Computer Science noted that direct recording equipment (DRE) voting machines have been used for years without a

Voting Equipment

There are two primary types of electronic voting equipment. The first type is direct recording equipment (DRE), which typically uses "touch screens" that display an electronic ballot and require users to select their choices by touching the screen. The second type are optical scan (OS) machines, which are scanners that read paper optical scan ballots completed by voters. These paper ballots are often different from paper ballots that are hand counted, and not for use in optical scan machines.

verified incident of tampering. He did acknowledge, however, the public perception that DREs are subject to tampering, in part because of several well-publicized studies pointing to potential security problems.

- Other experts pointed to vulnerabilities with DRE systems, especially that DREs are potentially vulnerable to hacking or inadvertent programming error.
- Several local election officials, speaking on behalf of both election staff and voters in their jurisdiction, expressed satisfaction with the DREs being used in their locality.
- Virginia Verified Voting, the Virginia chapter of a national organization concerned with voters' rights, and other individuals questioned the security of DREs and other electronic voting equipment—citing the need for some type of audit or paper trail.

The second factor discussed in the final joint subcommittee report was recommended legislation requiring post-election audits of voting equipment. The language of the recommended legislation directed each electoral board to randomly select at least five percent of precincts for a post-election audit. The audited precincts were to include all years and models of DREs and optical scan (OS) machines. House Bill 1243 that included this language was introduced during the 2006 General Assembly to implement the audit requirement. The bill was continued to 2007 in a voice vote by the Appropriations Committee, but was then left in committee during the 2007 General Assembly.

Though the legislation requiring post-election audits did not pass, there have since been two subsequent changes to the *Code of Virginia* that will be discussed throughout this report:

- In 2007, §24.2-626 of the *Code of Virginia* was amended such that after July 1, 2007, "no county or city shall acquire any direct recording electronic machine for use in elections … DREs acquired prior to July 1, 2007 may be used in elections … for the remainder of their useful life."
- In 2008, §24.2-671.1 of the *Code* was added to "provide for pilot programs in one or more localities … to conduct a post-election audit of one or more optical scan tabulators."

NATIONAL VOTING EQUIPMENT AND POST-ELECTION AUDIT LANDSCAPE

A seminal event in the debate around voting equipment and the need for audits was the recount of ballots and subsequent Supreme Court decision in the 2000 U.S. presidential election. As a result of

the controversy surrounding the voting equipment used—particularly in Florida—the Help America Vote Act (HAVA) was passed in 2002. The act was intended to accomplish a variety of objectives, including distribution of funding to states so they could replace older punch card voting systems with newer DREs and OS machines.

Virginia's HAVA implementation plan and report indicates that the State Board of Elections (SBE) allocated more than $24 million in federal HAVA funds to all 134 localities in Virginia. The plan indicates the funding was used to replace outdated voting equipment with HAVA compliant voting equipment. Localities had the flexibility to purchase various types of voting equipment from different vendors, as long as the equipment was certified by SBE. Using HAVA funds, all 134 localities purchased at least one DRE or other type of equipment accessible for disabled voters; some localities also purchased OS machines. This influx of federal funding, along with local flexibility to purchase different machines, contributed to a diversity of voting equipment across the State.

Amid this nationwide, federally funded effort to replace voting equipment, there has been ongoing discussion and debate about the reliability of voting equipment and the potential need to conduct audits. A 2004 report by the U.S. Government Accountability Office noted that "as older voting equipment has been replaced with newer electronic voting systems … the debate has shifted from hanging chads and butterfly ballots to vulnerabilities associated with DREs." The GAO report cites several examples of problems with DREs used in North Carolina, Florida, and California. More recently, HR 2894 introduced in June 2009 would amend HAVA to mandate, among other things, that all voting equipment is required to use a paper ballot, and that these ballots would be counted by hand in any subsequent recount or audit of election results. As of May 2010, there were 97 co-sponsors of the bill, which was referred to the Subcommittee on Technology and Innovation.

The debate has shifted from hanging chads and butterfly ballots to vulnerabilities associated with DREs.

Though there is no current federal requirement, almost half of the states conduct some form of post-election audit. Most of these states audit a fixed-percentage sample of ballots (typically from one to five percent) and conduct a manual, hand-to-eye count of the ballots.

VIRGINIA'S ELECTORAL PROCESS AND VOTING EQUIPMENT LANDSCAPE

Virginia's electoral process is governed by Title 24.2 of the *Code of Virginia*. The three-member SBE directs its staff regarding the agency's mission of promoting proper administration of Virginia's election laws. The SBE promulgates rules, regulations, and guid-

ance governing the election process. SBE also offers assistance to localities, upon request. At the local level, each locality has a three-member electoral board which sets local election policy, in accordance with the State election policy as articulated in statute and regulations. Each local electoral board employs a general registrar who, depending on locality size, directs a staff to carry out the election according to policy set by the General Assembly, SBE, and local electoral board.

Virginia's Electoral Process

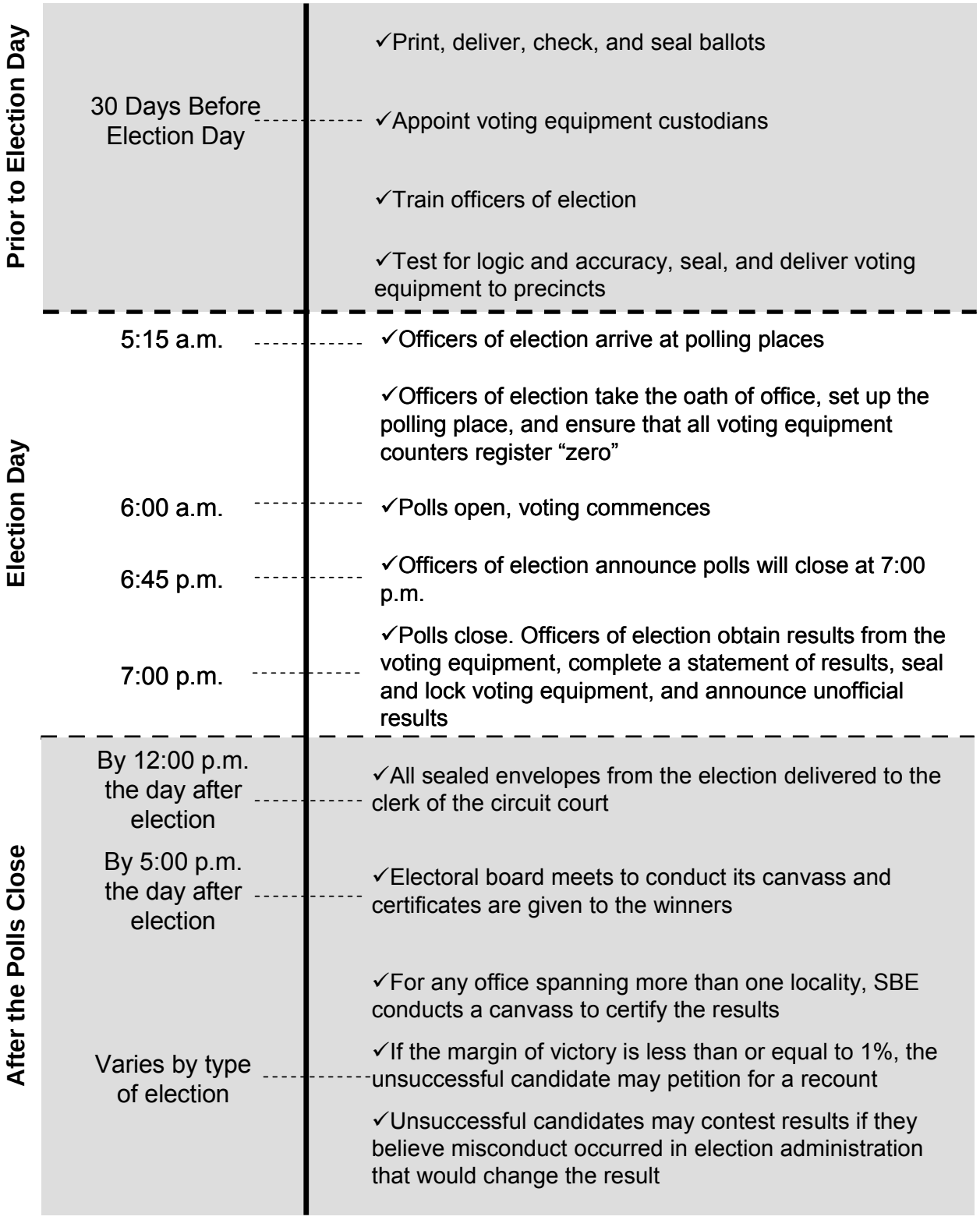
Through the *Code of Virginia,* the General Assembly has provided SBE and local electoral boards with specific direction about how elections should be conducted in the Commonwealth. The *Code* specifies what localities and SBE should do prior to election day to prepare to hold the election, on election day, and then after the polls close. A timeline of some of the key aspects of Virginia's electoral process is presented in Figure 1.

Prior to election day, a variety of activities must take place, including gaining SBE approval for and printing ballots, appointing voting equipment custodians, training officers of election, conducting logic and accuracy testing on each piece of equipment to be used in the election, and delivering ballots (if necessary) and voting equipment to each precinct. The *Code* provides extensive guidance about how election day should unfold at polling places across the Commonwealth, including requiring officers of election to report to polling places by 5:15 a.m. on election day, and to examine the equipment to ensure that it does not appear to have been tampered with and the counters register "zero."

The polls must open at 6:00 a.m., and they must be declared closed at 7:00 p.m. Once the polls close, officers of election obtain results from the voting equipment, record the results on statements of results, and announce the results to anyone waiting for results outside the polling place. The election materials are delivered to the clerk of the circuit court where the election took place by noon on the day following the election.

By 5:00 p.m. the day following the election, the local electoral board should meet to conduct its canvass of the results and certify the results. Next, the SBE meets to conduct its canvass, and it determines the total number of votes for any election crossing more than one local jurisdiction (for example, members of the General Assembly or U.S. Congress). Once SBE determines the results of the election, it completes a statement of results and issues certificates of election to the winners.

Figure 1: Timeline of Virginia's Electoral Process



Source: *Code of Virginia* Title 24.2, Virginia State Board of Elections (SBE), and JLARC staff analysis.

The Code of Virginia allows for recounts in any election where the margin of victory between the top two candidates is less than or equal to one percent.

The *Code of Virginia* allows for recounts in any election where the margin of victory between the top two candidates is less than or equal to one percent (calculated as the winner total minus the defeated total, divided by the total votes for both, then multiplied by 100). In these close elections, the candidate who appears to have lost the election may petition for a recount. If the margin of victory is one-half percent or less, or if the requesting candidate ends-up winning the recount, localities pay the cost of the recount. In all other circumstances, the candidate requesting the recount is responsible for the costs. The *Code* includes specific recount procedures depending on whether paper ballots or voting equipment was used. Additionally, the *Code* allows unsuccessful candidates to contest election results if they believe that some misconduct occurred in the administration of the election, which if proven true, could change the election outcome.

Virginians Vote Using DREs or Optical Scan Machines

The *Code of Virginia* requires that localities purchase only voting equipment that is certified by SBE. The SBE has certified a variety of voting equipment for use in Virginia. As shown in Table 1, Virginia localities currently use 13 different models of voting equipment manufactured by several different vendors. Twelve of the models are either DREs or OS machines. The remaining model is voter assist technology used by disabled voters. The most common model is the Winvote, which is a DRE made by Election Services Online. The Edge and Accu-Vote are the next most common.

Table 1: Thirteen Different Models of Voting Equipment Are Used Across Virginia

Model	Vendor	Type	# of Virginia Localities Using
WINVOTE	Election Services Online[a]	DRE	33
EDGE	Sequoia Voting Systems	DRE	31
ACCU-VOTE OS	Premier Election Solutions[b]	Optical Scan	25
PATRIOT	Unilect Corporation	DRE	23
ACCU-VOTE TSX	Premier Election Solutions[b]	DRE	22
iVOTRONIC	Election Systems and Software	DRE	9
AVC	Sequoia Voting Systems	DRE	8
AUTOMARK	Election Systems and Software	Voter Assist	5
M100	Election Systems and Software	Optical Scan	4
eSLATE	Hart Intercivic	DRE	3
OPTECH IIIPE	Sequoia Voting Systems	Optical Scan	3
eSCAN	Hart Intercivic	Optical Scan	1
OPTECH INSIGHT	Sequoia Voting Systems	Optical Scan	1

[a]The Winvote machine was manufactured by Advanced Voting Solutions. However, Election Services Online now handles the service contracts for Winvote customers in Virginia.
[b]Election Systems and Software purchased Premier Election Solutions in 2009.

Source: JLARC staff analysis of SBE data.

Examples of a DRE and an OS machine are shown in Figure 2. OS machines tabulate a paper ballot which voters fill-out, by hand, and then feed into the machine. Most optical scan ballots require voters to either fill in ovals or connect lines next to the name of their candidate of choice for each office on the ballot. The OS machine then tabulates the ballot by scanning the ballot in the manner programmed for the ballot design of that particular precinct. After scanning and tabulating the ballot, the OS machine deposits the ballot into a locked drawer at the bottom of the machine.

DREs are typically "touch-screen" computer terminals, which allow a voter to make selections and cast a vote. The vote is recorded and stored on a removable memory card and an internal memory system. Recently, DRE vendors have developed attachments that can be used to create a voter-verifiable paper record (VVPR). The VVPR can serve as a paper back-up to be checked after elections. To date, SBE has not received any vendor requests to certify any VVPR printers for use in Virginia.

Since the introduction of DREs, concerns have been expressed regarding the security of these machines. Several studies indicate that DREs could be vulnerable to tampering; however, no verified incident of tampering with a DRE machine has occurred in Virginia. Nonetheless, these studies have created a public perception that DREs may endanger the integrity of elections. There are also examples of DREs, and to a lesser degree OS machines, not tabulating votes correctly.

Figure 2: Example Direct Recording Equipment and Optical Scan Machine

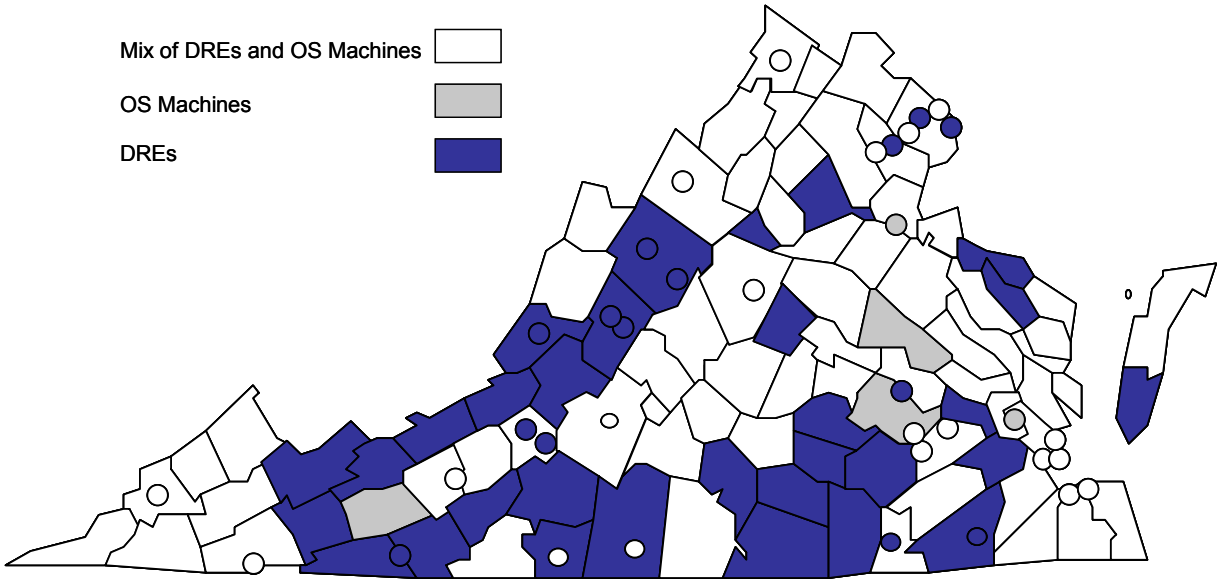
Direct Recording Equipment

Optical Scan Machine

Source: Election Systems and Software, Inc. and Fairfax County, Virginia.

Despite the recent statutory prohibition against purchasing additional DREs noted earlier in this chapter, DREs remain the most widely used type of voting equipment in Virginia. As shown in Figure 3, the majority of localities use a mix of both DREs and OS machines, while five use OS machines exclusively (other than for disabled or absentee voters). The remaining 45 localities use only DREs. As of March 2010, there were 4.98 million registered voters in Virginia. About 17 percent of these registered voters were in localities that use only DREs, while 77 percent were in localities that use a mix of both types of machines. The remaining six percent, or about 314,000 registered voters, were in localities that use only OS machines.

Figure 3: Most Virginia Localities Use a Mix of DREs and OS Machines



Note: Some localities have a slightly different equipment mix due to machines used in central absentee precincts or for accessibility of disabled voters.

Source: JLARC staff analysis of SBE data and JLARC staff survey of Virginia general registrars, 2010.

Chapter 2

Voting Equipment

In Summary

Voting equipment currently used by Virginia's localities has been certified nationally and by the State Board of Elections. Localities also conduct a relatively simple test on each machine prior to each election. Nevertheless, some computer scientists express skepticism about the security, accuracy, and reliability of both direct recording equipment (DRE) and optical scan (OS) machines. They are somewhat less concerned about OS machines because they use a paper ballot that can be audited. Several other states have conducted detailed reviews of their voting equipment, including some of the same models used in Virginia. These reviews have generally resulted in an increased reliance on OS machines and post-election audits, in addition to other technical and procedural changes. Virginia's general registrars express a very high degree of confidence in both the DREs and OS machines used by their localities. Virginia's general registrars tend to have an even higher degree of confidence in DREs than OS machines.

An important backdrop for considering post-election audits is the voting equipment being audited. Localities in Virginia currently use either direct recording equipment (DRE) or optical scan (OS) machines. Determining the extent to which post-election audits are necessary rests in part on the degree of certainty about the security, accuracy, and reliability of election results produced by each type of voting equipment.

EAC Now Performs National Certification

Between 1994 and 2007, the National Association of State Election Directors (NASED) administered a national voting equipment certification program. The Help America Vote Act mandated that the certification testing process be transferred from NASED to the newly created Election Assistance Commission (EAC). To date, the EAC has certified four models of voting equipment, none of which is used in Virgin-

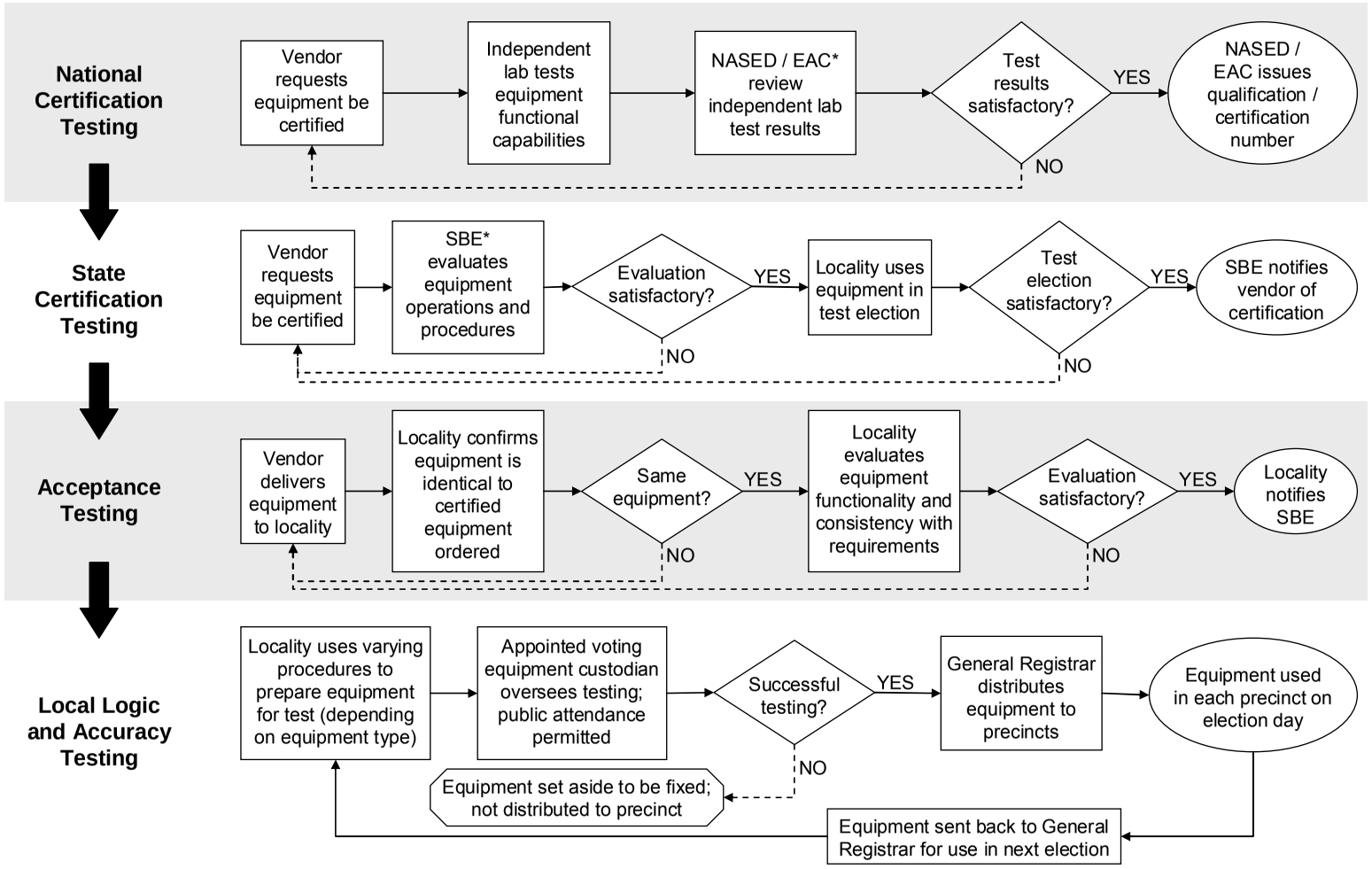
DREs AND OPTICAL SCAN MACHINES USED IN VIRGINIA HAVE BEEN CERTIFIED AND TESTED

The certification of voting equipment for use in Virginia consists of several phases (Figure 4). The process begins when a national entity tests and certifies the equipment. The National Association of State Election Directors (NASED) used to administer the national testing program, but since 2007 it has been administered by the Election Assistance Commission (EAC). There is also State-level certification, which in Virginia is conducted by the State Board of Elections (SBE). Localities then conduct acceptance testing once the equipment is delivered, and also conduct ongoing testing prior to the equipment being used in each election.

National Certification Testing

Typically, the national certification process is initiated when a vendor requests that its equipment be certified. The purpose of

Figure 4: National and Virginia Certification and Testing Process



Note: NASED, National Association of State Election Directors; EAC, Election Assistance Commission; SBE, State Board of Elections.

Source: JLARC staff analysis of EAC documentation, the *Code of Virginia*, and SBE policy.

national certification is to validate and document, through an independent testing process, that voting equipment meets the voting system performance guidelines and is consistent with the vendor's specifications. National certification testing is performed by accredited testing labs, which test voting equipment. The testing includes: examination of system software, tests of hardware under conditions similar to how it will be actually used, and operational tests to validate system performance and function. For older systems certified by NASED, such as those used in Virginia, an independent testing authority issued a qualification test report to the vendor and NASED. NASED then reviewed the test report, and if the voting equipment achieved satisfactory results, NASED issued a qualification number that remains valid for as long as the voting equipment is unchanged. For newer systems seeking EAC certification, the EAC reviews the test reports and determines whether the equipment achieved satisfactory results. If the results of the test are satisfactory, the EAC issues a certification number indicating the system has completed testing.

State Certification Testing

To initiate the State certification process, a voting equipment vendor sends the Secretary of SBE a letter requesting certification. The purpose of State certification testing is to verify that the design and performance of voting equipment complies with all applicable requirements in the *Code of Virginia*. State certification testing is also intended to verify that the equipment being tested is identical to the system that has been certified in the national process described above. Importantly, State certification is not intended to be an exhaustive test of voting equipment. The testing does, however, include defining ballot formats, installing application and election-specific programs and data in the ballot counting device, counting ballots, and obtaining data and audit reports.

To complete State certification, the equipment must be used in an actual "test" election in one or more localities. The election must be a general election in which write-ins are allowed. If the equipment performs satisfactorily in the test election, SBE will notify the vendor that the equipment will be certified.

Acceptance Testing

As part of the procurement process for voting equipment, a locality conducts acceptance testing. SBE policy requires localities to confirm that the equipment is identical to the certified equipment, and that the equipment is fully functional and capable of satisfying the locality's administrative and statutory requirements. Typically, acceptance testing consists of evaluating the equipment's func-

tionality, including: processing simulated ballots for each precinct in the locality, handling write-ins, generating a final report of the election, and producing audit logs. The locality then sends SBE a letter to confirm that the equipment received is identical to the certified equipment that it ordered.

Local Logic and Accuracy Testing

After a machine is certified nationally, by the State, and accepted by a locality, it is subject to less comprehensive testing prior to use in each election. This testing, known as logic and accuracy (L&A) testing, involves ensuring that each piece of equipment correctly tabulates votes. Logic and accuracy testing is conducted on all machines prior to each election. For each election, the local electoral board appoints a voting equipment custodian—which is usually an interested member of the public. The custodian oversees the L&A test, which the public may view if they wish.

The L&A test consists of programming the machine and running a small number of test ballots through the machine. The custodian knows how many votes for each candidate are in the test ballots. If the machine accurately counts the total number of ballots and votes, the counter is then set to zero, and the machine is locked and distributed to a local precinct for use on election day. After election day, the machines are returned to the general registrar, then stored for use until the next election. Because post-election audits are not required in Virginia, these L&A tests are the only ongoing process to test voting equipment.

CONCERNS REGARDING VOTING EQUIPMENT SECURITY, ACCURACY, AND RELIABILITY VARY

Security, Accuracy, and Reliability

According to a 2006 GAO report on voting equipment, security is a machine's vulnerability to attacks that would violate the election's integrity, and potentially impact the accuracy and reliability of the machine. Accuracy is defined as how frequently the equipment completely and correctly records and counts votes, and reliability is the extent to which the system performs as intended.

Despite the certification and testing process described above, computer scientists, voters' rights organizations, and some practitioners express concern about the security, accuracy, and reliability of both DREs and OS machines. Examples across the country, including in Virginia, of problems with voting equipment raise questions about whether machines operate properly during each election. One method of at least partially answering these questions is conducting a post-election audit on the voting equipment.

There are few discernable differences between DRE and OS machine security, accuracy, and reliability except for the fact that OS machines use a paper ballot that can easily be audited. Even if attachments that produce voter verifiable paper records are installed on DREs, the paper records are still not created directly by the voter and are cumbersome to audit. For this reason, those that believe audits are important and necessary advocate for the use of OS machines rather than DREs. These concerns were the primary

reason the General Assembly prohibited localities from purchasing new DRE equipment after 2007.

Some Computer Scientists Express Concern About Both Voting Equipment Types, but Are Less Concerned About OS Machines Because of Paper Ballot

As the National Research Council indicated in its 2005 study of electronic voting, "security is a particularly elusive goal" for computer scientists because their "perspective can be summarized as a worst-case perspective—if a vulnerability cannot be ruled out, it is necessarily of concern." From this perspective, computer scientists have publicly aired major concerns regarding electronic voting equipment, which has fueled skepticism of electronic voting equipment, in particular DREs.

ACCURATE

ACCURATE, which stands for A Center for Correct, Usable, Reliable, Auditable, and Transparent Elections, is a multi-institution voting research center funded by the National Science Foundation. Principal investigators with the center are affiliated with institutions such as Johns Hopkins University, Rice University, the University of Iowa, SRI International, the University of California at Berkeley, and Stanford University.

According to some nationally renowned computer security experts, such as those with a National Science Foundation consortium ACCURATE (see sidebar), DREs and OS are equally susceptible to security threats. Recent studies have demonstrated both DREs and OS are susceptible to the three types of security threats: (1) integrity, (2) anonymity, and (3) availability. However, because OS machines use a voter-verified paper record, computer scientists seem to agree that OS machines present less risk than DREs.

Integrity threats describe attacks that "aim to change election totals," or diminish the machine's accuracy. For example, a single attacker could inject a virus or program onto the machine that would change results by erasing votes, adding votes, or switching votes. Computer security experts at ACCURATE indicated to JLARC staff that on most voting equipment types, such a virus could spread from one voting machine to others. Optical scan machines and DREs are equally susceptible to being injected with a malicious program or virus; however, with an OS machine, the attack should be caught if the paper ballots are subjected to either a post-election audit or recount. To successfully launch this attack on an OS machine, the attacker would need to somehow replace all the cast ballots with fake ballots matching the tainted electronic tally. Making such a ballot switch would be very difficult. Because of this, OS machines generally provide greater protection against integrity attacks than DREs.

Anonymity threats describe attacks that would compromise a voter's privacy and confidentiality in the voting booth. For example, some DREs record votes in the order they were cast. If the attacker could access the pollbook, likely requiring the participation of a poll worker, an attacker could identify how individual voters cast their votes. With both DREs and OS machines, these attacks would generally require the collusion of some poll workers to be

successful, which makes these attacks less likely to occur than an attack that would not require a conspiracy.

Finally, availability threats describe attacks that would disrupt the election. For example, an attacker could inject a virus or program that could disable or shut down the machine, which would prevent voters from casting votes. Additionally, if the goal of the attack was to merely disrupt the election, an attacker could physically damage the machine. However, for an OS machine, to truly disrupt the election the attacker would also need to destroy or steal the OS ballots; otherwise, voters could continue to cast ballots even if the machine were not functional. Again, the OS machine is less vulnerable to these availability threats when compared to a DRE because of its paper ballot.

Several States Have Identified Problems With Equipment Also Used in Virginia; Now Relying More on Paper Ballots and Audits

In response to computer scientists' criticisms of electronic voting equipment, California, Ohio, Maryland, and Florida have reviewed the voting equipment used in their states. These reviews included several voting machines also used in Virginia, in particular various versions of the Accu-vote machine. Each of these states found problems with the equipment and took a variety of actions, with a general trend towards the use of OS machines using a paper ballot. Table 2 (next page) summarizes the findings and actions taken by these four states in response to their voting equipment review. California, Florida, and Maryland eventually discontinued the use of DREs, while Ohio began allowing voters a choice of DREs or OS machines. Florida, Ohio, and California each added post-election audit requirements.

In Virginia, SBE staff informally monitor voting equipment developments in other states, such as the review findings issued by Maryland, Florida, Ohio, and California. However, SBE has not taken any action regarding the findings of these studies. SBE staff noted that, while not directly in response to these other state reviews, the General Assembly has taken action to address skepticism regarding electronic voting equipment, including prohibiting the future purchase of DREs.

Virginia General Registrars Are Very Confident in Virginia's Equipment, Slightly More Confident in DREs

Though aware of the concerns of computer scientists and certain actions taken by other states, Virginia's general registrars still report a high degree of confidence in their locality's voting equipment. On a JLARC staff survey of Virginia general registrars, 95

Table 2: Findings and Actions Taken by Other States That Reviewed Voting Equipment Also Used in Virginia

	Virginia Voting Equipment Included in Review	Other State Reviews	
		Findings	*Actions*
California	• Accu-Vote-TSX (Premier) • Accu-Vote-OS (Premier) • eScan and eSlate (Hart Intercivic) • AVC Edge and Optech Insight (Sequoia)	• Substantial vulnerabilities in all equipment tested, including both DRE and OS machine models. • All systems contained "serious design flaws that have led directly to specific vulnerabilities," and that the security mechanisms provided by the vendors were not adequate to ensure election integrity and security.	• De-certified all equipment tested and re-certified it with conditions on its use, such as: o allowing two types of DREs to only be used for early voting and voters with disabilities, o requiring that all software be re-installed, and o adopting post-election audit escalation procedures when election results are within certain margins.
Maryland	• Accu-Vote-TS (Premier)	• Substantial vulnerabilities in the voting system; however, many of the identified vulnerabilities could be mitigated through implementing certain security procedures at storage locations and polling places. • Security procedures could mitigate some risks, but in the longer term, a "pervasive code re-write" and paper receipts were needed for auditability.	• Instituted a number of procedural safeguards recommended in the reviews. • In 2009, Maryland General Assembly passed a bill that will require that state to begin using OS machines for all elections.
Florida	• iVotronic (ES&S) • Accu-Vote-TSX and Accu-Vote-OS (Premier)	• Despite identifying a number of software and security vulnerabilities, the DRE did not cause, contribute, or create the higher than expected under-vote in the election. • Many previously-reported flaws had been remedied, but a number of flaws still existed that could threaten election integrity.	• State law changed to require paper ballots, except for voters with disabilities who may use an accessible DRE. • State law also changed to require post-election audits following the certification of each election. • Secretary of State developed and instituted its own equipment testing and certification program.
Ohio	•Accu-Vote-TSX and Accu-Vote-OS (Premier) •M-650, iVotronic, and M-100 (ES&S) •eSlate and eScan (Hart Intercivic)	• All voting systems studied, including both DRE and OS models, contain substantial security and reliability vulnerabilities that could compromise the integrity of an election. • While many potential threats would require a high degree of technical sophistication, other simple methods could be successfully deployed against the equipment that could compromise an election.	• Issued directives requiring localities using DREs to give voters the choice of using a paper ballot. • Required post-election audits, and • Developed procedural guidebooks to help localities improve security at storage locations and polling places.

Source: JLARC staff analysis of various other state audit reports or assessments.

JLARC Staff Survey of Virginia General Registrars

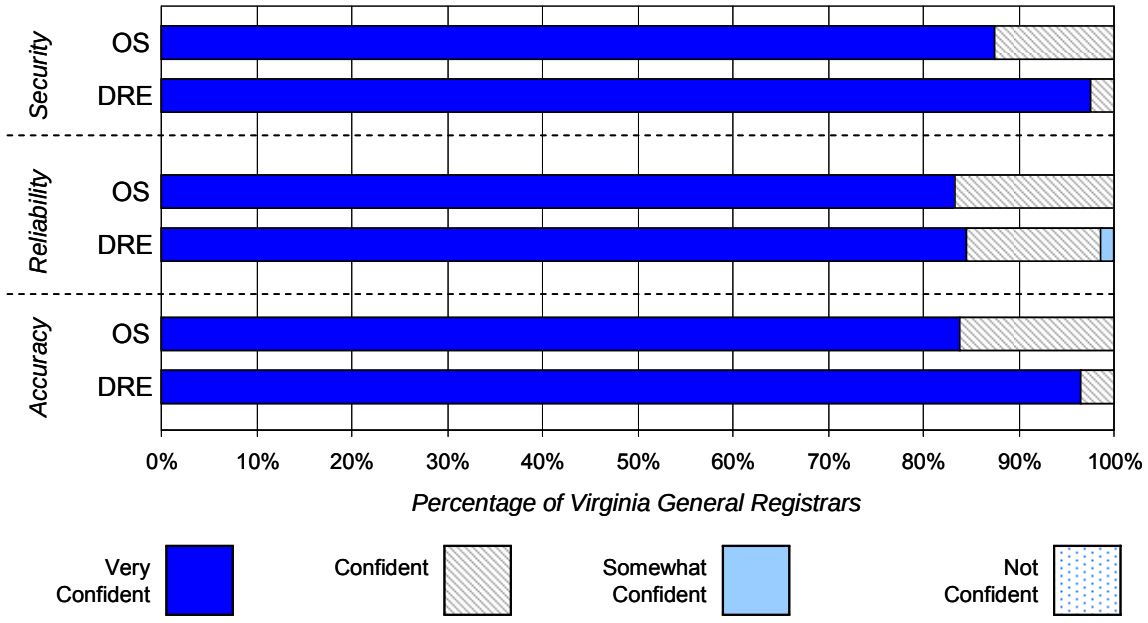
In February 2010, JLARC staff worked with the Voter Registrars' Association of Virginia to administer an online survey to Virginia's general registrars. JLARC staff received 110 responses from the 134 general registrars--for a response rate of 82 percent. More information about this survey can be found in Appendix B.

percent reported being very confident in the security of election results. Ninety-four percent were very confident in the accuracy, while 84 percent were very confident in equipment reliability.

As shown in Figure 5, within this generally high level of confidence there is a slight degree of variation depending on whether the voting equipment is OS machines or DREs. A modestly higher percentage (98 percent compared to 86 percent) of registrars reported being very confident in the security of DREs. A slightly larger difference (97 percent compared to 82 percent) reported being very confident in the accuracy of DREs. This somewhat higher degree of confidence in DREs than OS machines among Virginia registrars suggests that they do not share the concerns expressed by computer scientists and some other states noted above.

With the prohibition on purchasing new DREs, localities currently using DREs will at some point need to purchase new equipment. Localities using DREs cited a lack of funding to purchase new equipment, and the fact that their DREs did not need to be replaced yet, as the primary reasons for not yet transitioning to OS machines. Eleven localities reported their DREs will need to be replaced within two years, while another 20 estimated a three- to five-year replacement timeframe. The remaining localities that use DREs estimated it will be more than five years, or did not know when they would need to be replaced. This suggests that DREs will continue to be used across Virginia for at least the next five years.

Figure 5: Virginia's General Registrars Express Confidence in Voting Equipment



Source: JLARC staff survey of Virginia general registrars, February 2010.

Chapter 3

Post-election Audits in Other States

In Summary

Twenty-three states require post-election audits, while the remaining 27 states do not. States that do conduct audits implement them to achieve various purposes, such as enhancing election transparency and voter confidence. Most of these states use a fixed-percentage audit strategy, while a few use adjustable-percentage strategies in which larger sample sizes are selected for audit as the margin of victory narrows. States use several different audit methods to conduct their audits, but most use a hand-to-eye, or manual, counting method. Audit completion times can depend on the number of races audited, number of ballots included in a precinct selected for audit, and whether a discrepancy is found that needs to be reconciled. States report that the vast majority of their audits do not find substantial discrepancies. Audits do, however, at times find discrepancies that are typically attributed to factors such as a voter incorrectly filling out a ballot.

Senate Joint Resolution 328 directs JLARC staff to review the experience of post-election audits in other states. There is currently no federal requirement for states to conduct post-election audits, and more than half of the nation's states—including Virginia—have chosen not to require audits. Virginia's deliberations surrounding post-election audits can be informed by the purposes, strategies and methods, and results associated with audits conducted by other states.

TWENTY-SEVEN STATES DO NOT REQUIRE POST-ELECTION AUDITS, WHILE 23 STATES DO

According to the Center for Democracy and Election Management at American University, 23 states have some type of post-election audit requirement, while the remaining 27 states do not (Figure 6). In general, states in the mid-west and southeast tend to be those that do not require audits. States along the west coast and in the southwest tend to be those that do require some form of post-election audit. Some states, such as California, have had audit programs for many years. Other states, such as Tennessee, have only recently begun their post-election audit programs. Maryland is the only state that borders Virginia that does not currently require post-election audits on a regular basis.

Figure 6: Twenty-seven States Do Not Require Post-election Audits

Note: Though not shown, Alaska and Hawaii also require post-election audits.

Source: Center for Democracy and Election Management, American University, 2009.

JLARC Staff Survey of Other States

In January and February 2010, JLARC staff worked with the National Association of State Election Directors to administer an online survey to other states. JLARC staff received 25 responses, 11 from states that do not require audits and 13 states plus the District of Columbia which do require audits. More information about this survey can be found in Appendix B.

JLARC staff collected information from 11 states that do not require audits (see sidebar). In general, they cited various reasons for not conducting audits, including that they did not believe audits would add value to the election process or that their existing contest and recount provisions made post-election audits unnecessary.

A small number of states have the option to conduct audits if they wish, but have no statutory requirement for an ongoing post-election audit program. For example, Vermont reported that it does not have an ongoing post-election audit requirement, but that its Office of the Secretary of State is authorized to randomly conduct audits as it sees fit. Ohio also does not require post-election audits, but its Secretary of State has conducted some audits under a pilot program.

OTHER STATES AUDIT FOR VARIOUS PURPOSES AND USE SEVERAL AUDIT STRATEGIES AND METHODS

JLARC staff collected information from 13 states and the District of Columbia (D.C.) about their post-election audit programs. These states and D.C. have each implemented different programs, but some patterns do exist that can provide some insight for states such as Virginia studying post-election audits. An exhibit showing each state's and D.C.'s responses to certain survey questions is provided in Appendix D.

Majority of States That Conduct Audits Find Them Useful for a Variety of Purposes and an Effective Use of Resources

In general, other states require post-election audits to achieve several related purposes. Of 13 states (and D.C.) JLARC staff collected information from that do require post-election audits, most reported they found audits very useful for enhancing the transparency of the election and increasing voter confidence. Most of these states also reported that audits were very useful to verify election results and check the accuracy of voting equipment. Most of these states also characterized their post-election audits as a highly effective or effective use of resources. One state, however, reported its audits were not an effective use of resources.

Most States Use a Fixed-Percentage Audit Strategy to Determine Audit Sample Size

States that require post-election audits use either (1) a fixed-percentage audit strategy (FP), (2) an adjustable-percentage (AP) audit strategy designed to achieve a certain level of statistical confidence, or (3) a combination of the two. The majority of states that require audits use a FP strategy. Several states noted, however, that they would now recommend a strategy similar to the AP that would result in larger sample sizes as the margin of victory narrows. In this respect, Colorado noted that it is redesigning its current FP strategy to be one that, similar to an AP strategy, determines sample size based on limiting the risk that the election result was incorrect. North Carolina uses an AP strategy in which a statistician selects the appropriate sample size once the results of the election are known. The sample size is designed to achieve a 99 percent level of confidence that the winner on election night was the actual winner. To accomplish this, North Carolina typically has found that auditing two precincts in most localities and more precincts in the largest localities achieves an appropriate level of statistical confidence.

Most States Use Hand-to-eye Count or Combined Audit Method

States that require audits use either a (1) hand-to-eye counting (HTEC) audit method, (2) machine-assisted (MA) method, or (3) a combination of both. Only one state reported to JLARC that it uses only the MA method, while the remaining states reported either using the HTEC method or a combination of that method and the MA method.

Concern About Hand Count Audit Method

In 2006, Georgia published a report on a pilot post-election audit it conducted in selected localities. Georgia election officials noted particular concern about the increased opportunity for human errors in the hand-counting of the individual votes on the paper roll produced by the DRE.

Other states cite some differences between these audit methods. For example, Wisconsin noted that conducting a HTEC on OS ballots can make it difficult to determine with a high degree of certainty whether the machine should have counted a ballot with a partially filled oval or arrow. If these ballots are not fed back through an OS machine, it can be unclear whether the machine tabulated the ballot on election night. In terms of the MA method, California found that while it can minimize the time and labor necessary to conduct the post-election audit, each locality conducting the audit would need to acquire at least one spare machine to use for the machine-assisted audit. This machine would require programming and auditing.

States Report Varying Resources and Costs For Their Post-election Audits

Whether states rely more heavily on machines or people to conduct their audits, the resources for audits are typically provided at the local level. Most of the states that conduct audits fund them using primarily local funds. In most cases, either local election staff or poll worker volunteers serve on the audit teams.

Minnesota Reports Varying Times to Conduct Audits

In a report issued after the state's 2008 post-election audit of the general election, Minnesota reported that, on average, 12 ballots were counted per minute and the average audit completion time was 163.3 minutes. However, some audit locations took longer than others and there are many possible explanations for the varying audit times across the state.

Other states report varying numbers of audit officials and time to complete their audits. Illinois reports it uses one audit official per precinct, while Nevada reports it uses six. In most cases it appears states use teams of two or three people to conduct the counting. Most states reported it takes one to two hours for a team of audit officials to audit a precinct. Numerous factors appear to affect the number of people and time required to audit a given precinct, including

- what type of voting equipment used during the election was subject to audit;
- whether a HTEC, MA, or combination audit method is used;
- the number of races on the ballot included in the audit;
- the number of ballots cast in the precincts being audited; and
- whether discrepancies are found during the audit that must be reconciled through re-counting or additional auditing.

Furthermore, the amount of planning, set up, and audit close-out time surrounding the actual audit itself can vary substantially. Some states include this time in their estimates, while others may not.

Most States With Post-election Audits Conduct Them Prior to Certifying Election Results

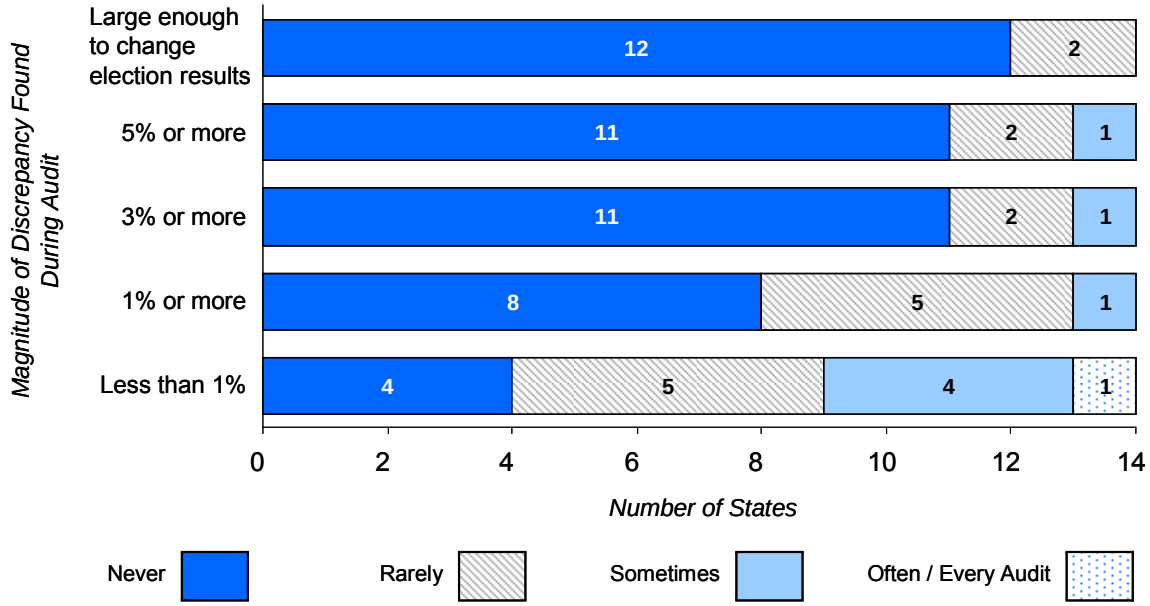
Most of the 13 states responding to the JLARC staff survey, as well as D.C., conduct their audits before election results are officially certified. Alternatively, Arizona and Florida conduct their audits after election results are certified, but prior to the deadline to file a petition for a recount. Wisconsin conducts its audits after results are certified and after the deadline to file for a recount. Eight of these 13 states that require post-election audits also reported having a law that triggers a recount if the margin of victory is below a certain threshold.

MOST AUDITS IN OTHER STATES DO NOT FIND SUBSTANTIAL DISCREPENCIES

As shown in Figure 7, other states' experiences with post-election audits suggest that in the vast majority of audits conducted, discrepancies that are found do not change the outcome of the election. Of the 13 states (and D.C.) that conduct audits JLARC staff collected information from, most report that they have never found a discrepancy between election night and audit tallies that was large enough to change the initial election results. States that have formally reported on the results of their audits reached similar conclusions (Table 3). On the survey, Illinois reported it sometimes found discrepancies of five percent or greater, while Montana and Arkansas reported they rarely find discrepancies large enough to change the election results.

The 13 states and D.C. reported a variety of responses to finding discrepancies that arise during their post-election audits, including publicizing the discrepancies and pulling a larger sample of ballots or conducting a full recount of ballots. Incorrect completion of ballots by voters was the most frequently cited reason for what typically account for discrepancies between the election night and audit tally. Other factors cited were errors in reporting the results of the count, errors in setting up the voting equipment, or errors in the HTEC during the audit.

Figure 7: Most States' Audits Do Not Find Substantial Discrepancies



Source: JLARC staff analysis of information provided by 13 other states and the District of Columbia that conduct post-election audits.

Table 3: States' Published Audit Reports Typically Validate Election Results

State / Election Audited	Observation About Audit Result
Minnesota, November 2008 General Election	The voting machines used in the audited precincts were shown to be accurate. Two hundred seven OS machine errors were found, resulting in an accuracy rate of 99.946 percent for the audited machines.
North Carolina, November 2008 General Election	North Carolina concluded that the statistical probability that the declared winner of the presidential race in fact won the North Carolina election was higher than 99.9 percent.
Georgia, November 2006 General Election	The manual audit conducted in three pilot precincts successfully verified that the electronic votes cast matched the votes reported on the VVPAT in every precinct and for every race.
New Mexico, Simulation of 2006 General Election	Average differences between the first machine count and the two person hand count averaged 0.19 percent and differences between the first machine count and the three person hand count averaged 0.13 percent.

Source: JLARC staff analysis of other state audit reports or assessments.

Chapter 4

Virginia's Post-election Audit Pilot Project

In Summary

JLARC staff worked with the State Board of Elections (SBE), the City of Charlottesville, and Chesterfield, Fairfax, and Page Counties to conduct a series of pilot post-election audits. A different model of optical scan machine was audited in each locality, using both hand-to-eye count and machine-assisted audit methods. The time required to complete the audits varied and depended on the number of ballots included in the precinct, audit method used, and whether it was necessary to reconcile differences between the election day and audit day totals. The election day and audit day totals exactly matched in two localities, and were very close in the other two localities. The results of the pilot audits provided several lessons. For example, audit officials identified isolated instances in which an optical scan machine did not tabulate a ballot that was improperly completed by a voter. SBE and localities may wish to assess the feasibility of reducing the instances in which a ballot that can be read by a human is not tabulated by an optical scan machine.

Section 24.2-671.1 of the *Code of Virginia* authorizes the State Board of Elections (SBE) to provide for pilot programs for audits of optical scan (OS) machines. JLARC staff examined the data, procedures, results, and conclusions of the pilot audit working with SBE staff, and general registrars, electoral boards, and clerks of the circuit court in four localities.

PILOT POST-ELECTION AUDIT METHODOLOGY AND PLANNING

JLARC staff worked with SBE staff, the Virginia Electoral Board Association, and the Voter Registrars' Association of Virginia to ask localities to participate in the pilot. Four localities that use OS machines volunteered: the City of Charlottesville, and Chesterfield, Fairfax, and Page Counties. Once general agreement was reached with these localities on participation, JLARC staff began developing a proposed audit approach. This approach was shared with these localities, SBE, the Democratic and Republican Parties of Virginia, as well as Virginia Verified Voting. Feedback from these groups was incorporated as appropriate, culminating in an audit guidebook, instructions, and forms to be used in each locality. These materials were developed using two primary sources: (1) existing SBE policy for recounts in Virginia and (2) other states' methods of post-election audits.

After the November 2009 election results were available, JLARC staff analyzed the results of each election on the ballot in each pre-

cinct in the four participating localities. Races and precincts were selected based on statutory requirements, essentially intended to audit races with substantial margins of victory. More information about this race and precinct selection process can be found in Appendix B.

JLARC staff then notified each candidate on each ballot in each precinct selected for audit. The State and local Democratic and Republican parties were also notified. On January 15, 2010, SBE approved the general approach for the pilot audit project, as well as the required notification to the clerk of the circuit court in each of the four localities that would allow access to the ballots.

PILOT POST-ELECTION AUDIT TIME REQUIREMENTS AND RESULTS

The pilot post-election audits were conducted in February and March 2010 (Table 4). Several different races from elections held in 2009 were audited, and the audits used two different types of audit methods: hand-to-eye count (HTEC) or machine-assisted (MA). The HTEC method, also known as the manual counting method, consists of physically counting the ballots by hand. There are several variations of the HTEC method that were used during the audits, including sorting and stacking the ballots by candidate, and a call and tally method in which one audit official called the vote and the other audit official marked which candidate received the vote on a tally sheet. One of these variations of the HTEC method was used in all four pilot audits. The MA method used in Charlottesville and Fairfax County consisted of feeding the ballots cast on election day back through an OS machine. The audit results were produced by having the machine tabulate the ballots, and then print a tape indicating how many votes each candidate received. Examples of the HTEC and MA audit methods used in two of the localities are shown in Figure 8.

Table 4: JLARC Staff and Localities Conducted Four Post-election Audits

Locality	Audit Date	Race Audited	Audit Method
Page County	February 3, 2010	2009 Attorney General	HTEC
Charlottesville	February 18, 2010	2009 Democratic Primary, Governor	HTEC and MA
Chesterfield County	March 10, 2010	2009 Attorney General	HTEC
Fairfax County	March 15, 2010	2009 General Assembly, District 45	HTEC and MA

Source: JLARC staff.

Figure 8: Examples of HTEC and MA Audit Methods

Ballots Sorted on Tables Using Hand-to-eye Count Method in Chesterfield County

Ballots Tabulated Using Machine-assisted Counting Method in Fairfax County

Source: JLARC staff photos taken at the Chesterfield County and Fairfax County post-election audits on March 10 and 15, 2010.

Time Required to Audit a Precinct Varied and Depended on Audit Method, Precinct Size, and Extent of Reconciliation Needed

As shown in Tables 5 and 6, the audits took anywhere from three minutes to more than three hours. Across all audits conducted, between 1.5 and 12.5 ballots were audited per minute, per audit official. This wide range is due to the different audit methods used, numbers of ballots included in the precinct, and whether reconciliation was necessary after obtaining an initial total and comparing it to the election day total. Reconciliation consists of re-

Table 5: HTEC Audit Method Times

Locality	Precinct	HTEC Variation Used	Reconciliation Required After First Count	Ballots Audited	Audit Time (min)	Ballots Audited / Minute / Audit Official
Page County	501	Sorting / Stacking[a]	Yes	1,054	193	2.7
Page County	401	Sorting / Stacking	Yes	905	112	4.0
Charlottesville	Absentee	Call and tally	No	41	3	6.8
Chesterfield County	511	Sorting / Stacking	Yes	1,230	111	3.7
Chesterfield County	307	Sorting / Stacking	Yes	1,212	69	5.9
Fairfax County	408	Sorting	Yes	519	71	3.6
Fairfax County	608	Sorting	Yes	902	91	5.0
Fairfax County	621	Sorting	No	439	28	7.8

[a] The total number of ballots was tabulated first as a separate step prior to sorting and stacking the ballots by candidate in this precinct. These steps were combined in subsequent HTEC audits.

Source: JLARC staff analysis of Virginia post-election audit pilot project.

Table 6: MA Audit Method Times

Locality	Precinct	Ballots Audited	Audit Time (min)	Ballots Audited / Minute
Charlottesville	Absentee	41	28	1.5
Fairfax County	408	519	50	10.4
Fairfax County	608	902	72	12.5
Fairfax County	621	439	42	10.5

Source: JLARC staff analysis of Virginia post-election audit pilot project.

examining and/or recounting the initial tally to try to find a reason for any differences between the initial audit total and election day total.

In general, the MA method allowed audit officials to count more ballots per minute than using the HTEC method. Variations of the HTEC method were used in some of the localities, which also appeared to impact the time required to complete the audit. Audit officials were generally able to audit precincts with fewer ballots in less time. Audits that required reconciliation (that is, re-checking the number of ballots in stacks, or re-checking to make sure candidate ballots were correctly sorted) generally took more time.

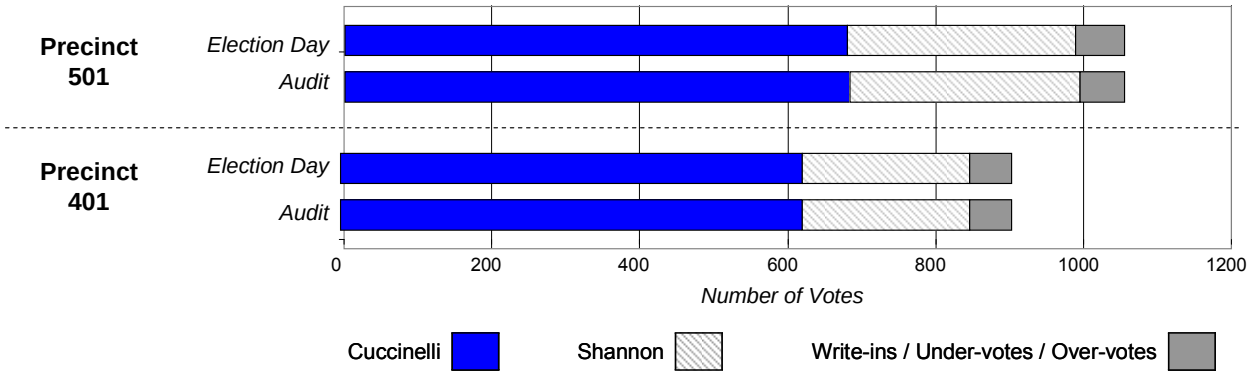
The longest audit was of precinct 501 in Page County. This audit used the most time-consuming variation of the HTEC method, included 1,054 ballots, and required reconciliation after the first count. The shortest HTEC audit (other than in Charlottesville, which was somewhat of an anomaly because it included only 41 ballots) was of precinct 621 in Fairfax County. This precinct had the fewest ballots (other than in Charlottesville), and no reconciliation was required after the first count because it matched the election day total.

Page County Audit Totals Very Close to Election Day Totals

Both precincts audited in Page County used an Optech IIIPE OS machine manufactured by Sequoia Voting Systems. As shown in Figure 9, the election day and audit day totals across both precincts audited were very close. The combined difference between the candidate totals in both precincts audited was 0.33 percent of the total votes cast for each candidate in both precincts.

The audit of precinct 501 concluded that there were four ballots cast for Cuccinelli and two ballots cast for Shannon that were most likely not read by the OS machine, but the voter intent could be determined by the audit official. This resulted in the audit day total being 0.59 percent higher for Cucinnelli and 0.65 percent higher for Shannon (Table 8 at the end of this chapter summarizes all candidate totals and differences for each precinct audited).

Figure 9: Page County Post-election Audit Results



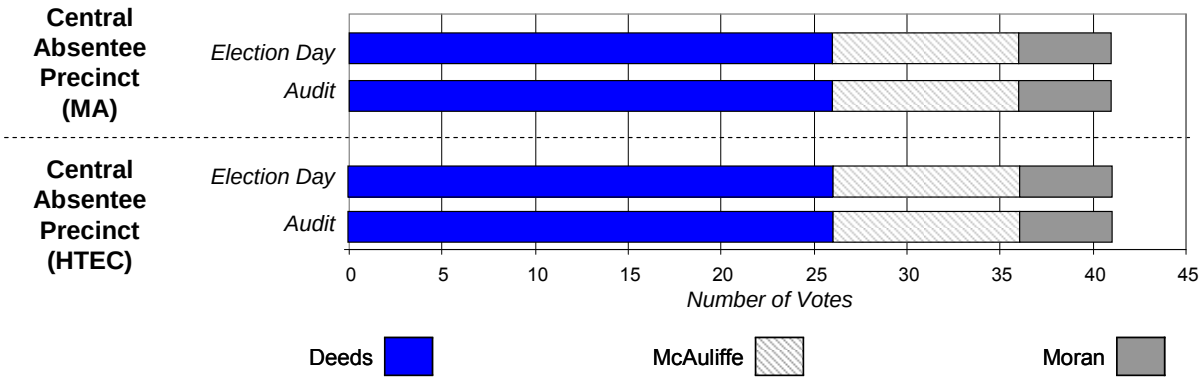
Source: JLARC staff analysis of Page County post-election audit conducted on February 3, 2010.

These ballots were likely tabulated as under-votes on election day. Cuccinelli won this precinct by 39 percent. The audit of Page County precinct 401 concluded that there was no difference between each candidate's election day and audit totals. This suggests that the OS machine accurately tabulated all ballots cast in that precinct on election day. Cuccinelli won this precinct by 43 percent.

Charlottesville Audit Totals Exactly Matched Election Day Totals

The central absentee precinct in Charlottesville used an eScan OS machine manufactured by Hart InterCivic. As shown in Figure 10, the election day and audit totals in both the MA and HTEC were the same. This suggests that the OS machine accurately tabulated all ballots in the central absentee precinct during the primary. Deeds won the central absentee precinct by 51 percent during the primary.

Figure 10: Charlottesville Post-election Audit Results

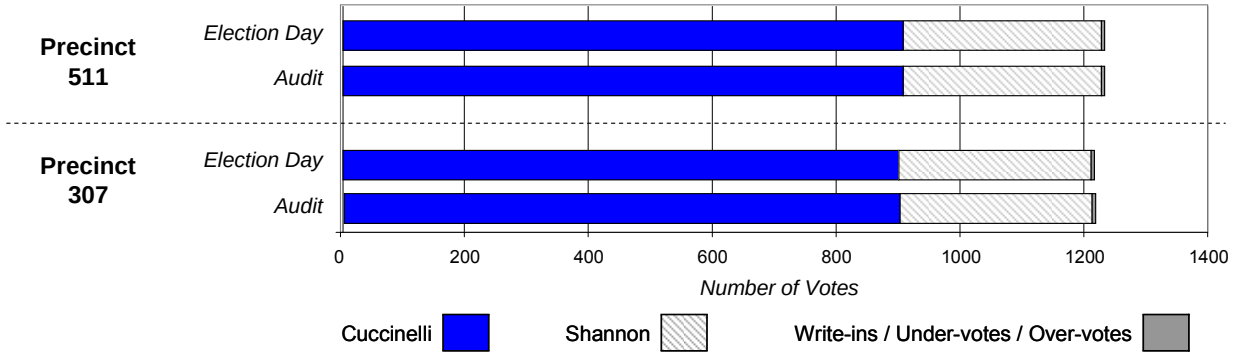


Source: JLARC staff analysis of Charlottesville post-election audit conducted on February 18, 2010.

Chesterfield County Audit Totals Exactly Matched Election Day Totals

Both precincts audited in Chesterfield County used an M-100 OS machine manufactured by Election Solutions and Software. As shown in Figure 11, the election day and audit totals in both precincts were the same. This suggests that the OS machine accurately tabulated all ballots cast in both precincts during the election. Cuccinelli won precinct 511 by 48 percent and precinct 307 by 49 percent. The Chesterfield general registrar noted that the locality's M-100 OS machines are programmed to the closest tolerance possible. This programming may have contributed to the fact that the election day and audit totals exactly matched in both precincts.

Figure 11: Chesterfield County Post-election Audit Results



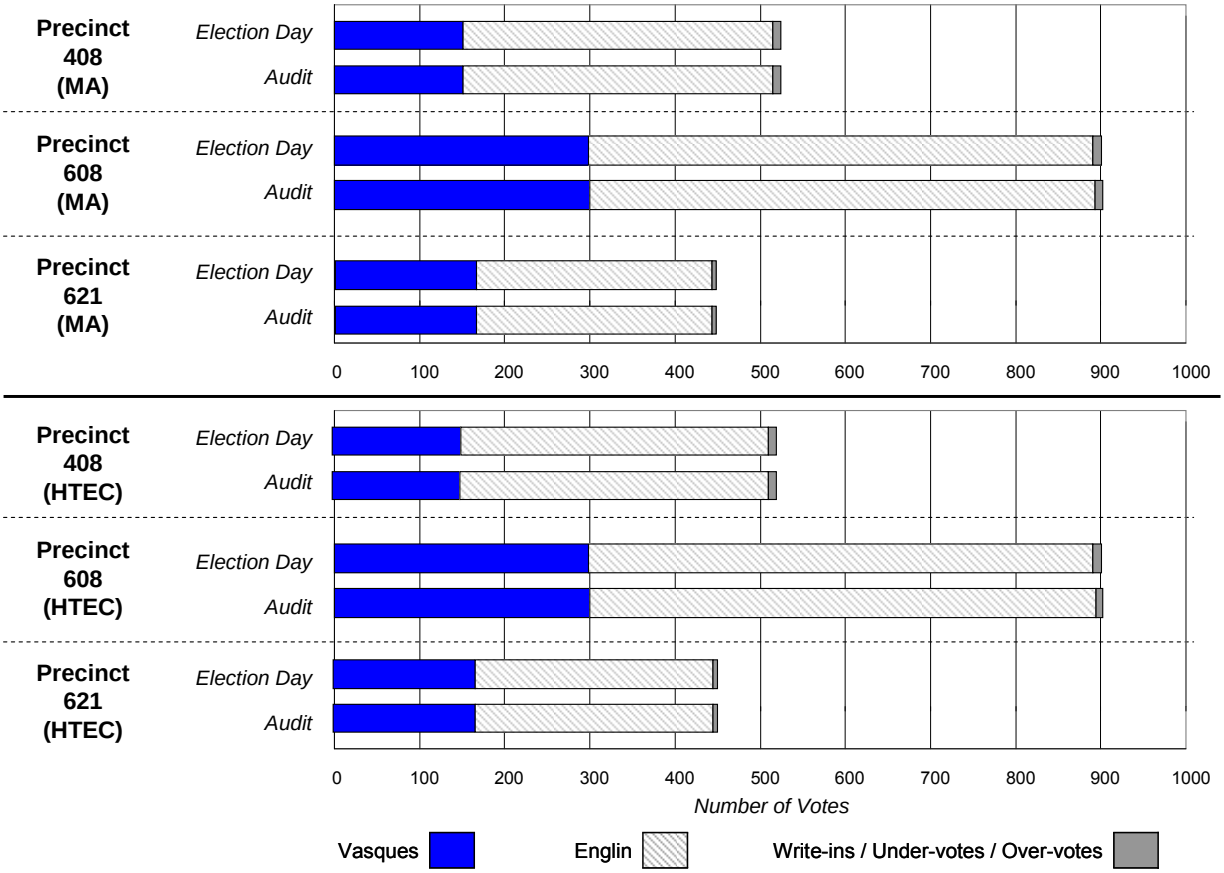
Source: JLARC staff analysis of Chesterfield County post-election audit conducted on March 10, 2010.

Fairfax County Audit Totals Close to Election Day Totals

Voters in all three precincts audited in Fairfax County had the choice of using a DRE or an Accu-Vote OS machine manufactured by Premier Election Solutions. The optical scan ballots were audited in each of the three precincts. As shown in Figure 12, the election day and audit totals were close, but varied in several instances. The difference between the candidate totals across all three precincts was 0.16 percent for the MA audit and 0.44 percent for the HTEC audit.

The MA audit of precinct 408 concluded that there was no difference between each candidate's election day and audit totals. The HTEC audit of this precinct concluded that there was one ballot that was most likely not read by the OS machine, but the voter intent could be determined by the audit official. The audit officials could not, however, explain other differences between the audit and election day totals. This resulted in the audit day total being 0.56 percent higher for Englin and 0.67 percent lower for Vasques. Englin won this precinct by 41 percent.

Figure 12: Fairfax County Post-election Audit Results



Source: JLARC staff analysis of Fairfax County post-election audit conducted on March 15, 2010.

The MA audit of precinct 608 concluded that that the OS machine counted one more ballot than what was counted on election day. Audit officials hypothesized that two votes attributed to candidates were likely votes that the machine was unable to read on election day and tabulated as under-votes, while a third additional vote attributed to one of the candidates was likely the additional ballot not counted on election night. The fact that the audit yielded one more ballot than the election night was difficult to explain. This resulted in the audit day total being 0.34 percent higher for Englin and 0.33 percent higher for Vasques. Englin won this precinct by 33 percent.

The HTEC audit of precinct 608 concluded that the election day and audit totals differed for a variety of reasons, some potentially explainable and others not as explainable. Audit officials hypothesized that four of the additional votes they had attributed to candidates were likely counted as under-votes by the OS machine on election day because the ballots were not completed according to the instructions given. They also concluded that a fifth additional

vote they had attributed to a candidate was likely the extra ballot that had not been counted on election day. However, it is unclear why a sixth vote had been attributed to a candidate, and—as with the MA audit—why one more ballot was counted during the audit than on election day. This resulted in the audit day total being 0.68 percent higher for Englin and 0.33 percent higher for Vasques. Englin's margin of victory in this precinct was 33 percent.

Both the MA and HTEC audits of precinct 621 concluded there was no difference between each candidate's election day totals and audit totals. This suggests that the OS machine accurately tabulated all ballots cast in that precinct on election day. Englin won this precinct by 25 percent on election day.

More detailed information about each of the four pilot audits discussed above is in Appendix C.

LESSONS LEARNED FROM VIRGINIA'S POST-ELECTION AUDIT PILOT PROJECT

Collectively, the findings from the four pilot audits provide some important lessons. The experiences of using varying audit methods and auditing precincts of varying sizes illustrated the differences between the two main audit methods. In addition, having access to optical scan ballots completed by voters provided information about the different ways voters complete ballots and the extent to which they can be read by a machine if not properly completed. Most importantly, the individual and collective error rates of the audits provide insight into the security, accuracy, and reliability of four different types of OS machines used in Virginia.

HTEC and MA Audit Methods Have Differences

The HTEC and MA audit methods used across the pilots, including the variations on the HTEC method, are different in terms of their ability to perform an audit quickly, tabulate votes accurately, and reconcile results completely (Table 7). In terms of the speed with which the audit can be completed, a HTEC is likely more efficient in precincts with smaller numbers of ballots because there is less set-up time required than with a MA audit. In addition to the machine's set-up, logic and accuracy testing, and break down, each ballot must be individually fed into the machine by an audit official (though some types of OS machines can be fitted with an automatic ballot feeder). As the number of ballots increases, though, a machine can tabulate more ballots in a given period of time than a human can. This has the effect of reducing the role that machine set-up, logic and accuracy testing, and break down play in the total time of the audit.

Table 7: Differences Between HTEC and MA Audit Methods

Characteristic	Audit Method	
	HTEC	***MA***
Speed	Faster for auditing smaller precincts	Faster for auditing larger precincts
Tabulation	More effective at determining voter intent when ballot not completed according to instructions given	More effective at determining what the machine should have tabulated on election day
Reconciliation	Provides a path to pursue (i.e., checking stacks of ballots again) if vote totals do not match election day totals	May be less necessary or valuable unless a different, separately programmed machine is available to conduct the audit again

Source: JLARC staff analysis of Virginia post-election audit project.

The two methods have differing abilities to tabulate votes as well. The audits showed that there were several instances when the HTEC could accurately tabulate a ballot that a machine could not. This was especially true in situations where the voter did not complete the ballot per the instructions given (often by not completely filling in or placing a check mark in an oval or rectangle) but the audit official could still clearly tell the voter's intent. On the other hand, the MA audit method had the advantage of providing a high degree of certainty about whether the machine likely read the ballot on election day. Without the assistance of a machine during the HTEC audits, audit officials could only speculate about whether the difference between the audit totals and election day totals was because the machine did not read the ballot.

Finally, when considering the reconciliation of audit results that do not match election day results, in most cases the HTEC method gives audit officials more viable reconciliation options. When the stacking and sorting HTEC variation was used, audit officials could check the number of ballots in each stack, and then ensure that each stack assigned to a particular candidate includes only ballots for that candidate. In contrast, both the MA audit method and the call and tally variation of the HTEC did not sort and stack ballots—therefore, reconciling would likely require starting over or using another method. Importantly, no audit method can completely replicate everything that may have occurred on election day. Consequently, there are instances in which the election day totals and audit totals do not match, and there is no way to explain the differences with any degree of certainty using either method.

No audit method can completely replicate everything that may have occurred on election day.

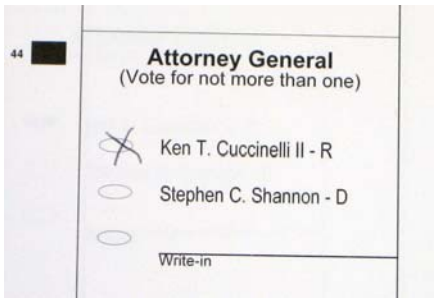
Optical Scan Machines Can Read Many, but Not All, Ballots Not Properly Completed by Voters

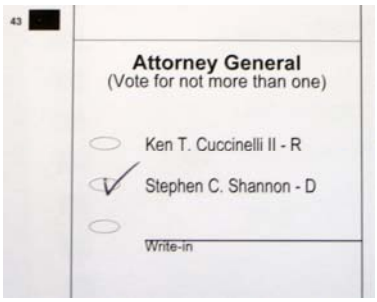
On one hand, the optical scan machines audited were adept in certain cases at tabulating ballots that were not completed according to the instructions given to the voter. The ballots shown in the top row in Figure 13 are two examples of several that were correctly tabulated on election day, despite the fact that the instructions were to fill in the oval. On the other hand, the HTEC audits found several instances in which a human could clearly determine the intent of the voter by looking at the ballot, but the OS machine could not tabulate the vote. Given the way that the OS machine was programmed, it was not reasonable to expect the machine to be able to tabulate these types of ballots. Nevertheless, in these cases, the person's vote was not tabulated. The ballots shown in the bottom row of Figure 13 are two examples that were not tabulated by the OS machine on election day, but an audit official could tell the voter's intent.

In terms of lessons learned, there are two considerations when determining whether it is feasible to reduce the instances when a person's vote is not tabulated—though they did not complete the ballot according to the instructions given. The first consideration is whether it is technically feasible to program the different models of

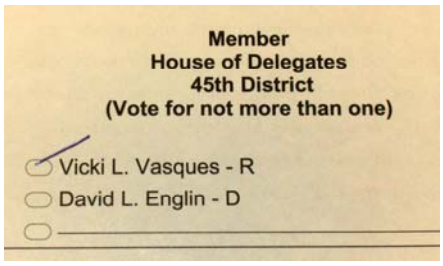
Figure 13: Examples of Incorrectly Completed Ballots Tabulated and Not Tabulated (Ovals Were To Be Filled In)

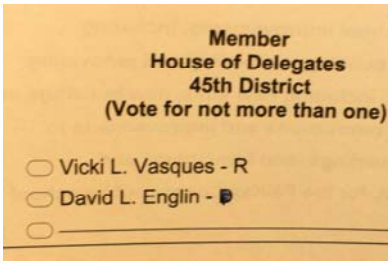
Votes Tablulated by M-100





Votes NOT Tablulated by Accu-Vote





Note: Instructions on ballots in both localities were for the voter to completely fill in the oval to the left of the candidate's name.

Source: JLARC staff photographs from Chesterfield County and Fairfax County post-election audit.

OS machines used in Virginia to better detect these types of ballots. Each type of machine has various thresholds for the minimum percentage of the area (whether it is an oval, rectangle, or line that must be completed) that can be marked by a voter and still be read by the machine.

Even if it is technically feasible, the logistical feasibility of addressing the issue also needs to be considered. Even if machines could be better programmed to detect instances in which they could not read a vote, the only likely recourse would be to notify the voter and give him or her the opportunity to improve the mark placed on the ballot. During busy times in a precinct on election day, this could cause potentially disruptive back-ups at the optical scan machine. When asked on the JLARC staff survey of Virginia general registrars, 41 of the 64 responding to the question—about two-thirds—thought programming their machines to alert voters about this could be either mildly or not very disruptive to voting at their precincts. Nine general registrars believed this could be highly disruptive, while 14 believed it could be disruptive.

Because such ballots represent instances in which a voter believes he or she has voted for a candidate, but in fact his or her vote is not counted, SBE and localities may wish to assess this issue further.

Because such ballots represent instances in which a voter believes he or she has voted for a candidate, but in fact his or her vote is not counted, SBE and localities may wish to assess this issue further. The assessment could consider both the technical feasibility and potential disruptive impact in precincts. The assessment could also examine the various methods of addressing the issue, which may include more precise programming of OS machines, more rigorous logic and accuracy testing, and/or changes to voter instructions or election day procedures.

Machine Error Rate

Voting equipment certification standards require machines to read at least 1,549,703 consecutive ballot positions correctly. However, because the pilot project design included counting only a single race, consecutive ballot positions—or all possible selections on the ballot—were not measured. Consequently, the difference between election day and audit totals for the pilot project cannot be readily compared to the certified error rate for the machines audited.

Differences Between Election Day and Audit Results Would Not Change Election Outcome in All But Closest Elections

The voting equipment certification standards in place when most of Virginia's voting equipment was purchased note that the error rate is "set at a sufficiently stringent level such that the likelihood of voting system errors affecting the outcome of an election is exceptionally remote even in the closest of elections." Considering this standard, none of the observed differences between the election day totals and audit day totals were large enough to affect the election day outcome.

As shown in Table 8, across all 12 audits conducted, the difference between election day and audit totals was 0.21 percent of all candidate vote totals on election day. In eight of the 12 precincts audited (counting each HTEC and each MA count as a separate audit activity), the election day and audit results matched exactly. In the remaining four precinct audits, there were differences of several

votes, resulting in a difference of between one-third and two-thirds of one percent.

The percentage differences observed across the four audits suggest that—when considering only votes cast on OS machines—the variations are well within the State's one-percent threshold for requesting a recount. In other words, only in circumstances when a candidate could request a recount would the differences observed in the pilot audits be of the same magnitude (or larger) than the election day margin of victory.

Table 8: Differences Between Election Day and Audit Candidate Totals

Locality, Precinct (Audit Method)	Candidate	Candidate Totals		Difference Between Election Day and Audit Candidate Totals	
		Election Day	*Audit*	*#*	*%*
Page 501 (HTEC)	Cuccinelli	679	683	4	-0.59%
	Shannon	309	311	2	-0.65
Page 401 (HTEC)	Cuccinelli	622	622	0	0.00
	Shannon	226	226	0	0.00
--Page County Totals--		*1,836*	*1,842*	*6*	*0.33*
Charlottesville CAP (MA)	Deeds	26	26	0	0.00
	McAuliffe	10	10	0	0.00
	Moran	5	5	0	0.00
Charlottesville CAP (HTEC)	Deeds	26	26	0	0.00
	McAuliffe	10	10	0	0.00
	Moran	5	5	0	0.00
--Charlottesville Totals--		*82*	*82*	*0*	*0.00*
Chesterfield 511 (HTEC)	Cuccinelli	905	905	0	0.00
	Shannon	318	318	0	0.00
Chesterfield 307 (HTEC)	Cuccinelli	897	897	0	0.00
	Shannon	311	311	0	0.00
--Chesterfield County Totals--		*2,431*	*2,431*	*0*	*0.00*
Fairfax 408 (MA)	Vasques	150	150	0	0.00
	Englin	360	360	0	0.00
Fairfax 608 (MA)	Vasques	299	300	1	-0.33
	Englin	591	593	2	-0.34
Fairfax 621 (MA)	Vasques	163	163	0	0.00
	Englin	271	271	0	0.00
Fairfax 408 (HTEC)	Vasques	150	149	1	0.67
	Englin	360	362	2	-0.56
Fairfax 608 (HTEC)	Vasques	299	300	1	-0.33
	Englin	591	595	4	-0.68
Fairfax 621 (HTEC)	Vasques	163	163	0	0.00
	Englin	271	271	0	0.00
--Fairfax County Totals[a]--		*3,668*	*3,677*	*11*	*0.30*
All-Audit Total[a]		**8,017**	**8,032**	**17**	**0.21%**

Note: Does not include write-ins, under-votes, and over-votes.

[a]Fairfax County and all-audit election day and audit day totals, when subtracted, do not equal what is shown in the difference between election day and audit day totals column. This is because in several cases positive and negative differences within precincts cancel each other out.

Source: JLARC staff analysis of Virginia's post-election audit pilot project.

Chapter 5

Time, Expenditures, and Statistical Considerations

In Summary

There are two primary statistical strategies for choosing the post-election audit sample size: the fixed-percentage (FP) strategy and the adjustable-percentage (AP) strategy. The strategy used to create the audit sample affects the ability to plan for the audit, the level of statistical confidence, the time required to conduct the audit, and the expenditures required to complete the audit. While the FP strategy is easier to plan for, it may not provide statistical confidence in the election outcome. The AP strategy does provide a high degree of statistical confidence, but its variable sample size makes it more difficult to plan for. An FP audit could require 5.5 to 6.2 hours, on average, to complete in each of Virginia's 134 localities. In total, all localities in Virginia could spend up to $148,000 to conduct an FP audit. In contrast, an average AP audit would involve fewer localities and require them to spend less time and money. However, in elections with small margins of victory, an AP audit could require almost the same amount of time and cost associated with a full recount.

JLARC staff reviewed alternative procedures and processes for post-election audits, estimated the time requirements and costs of post-election audits, and considered the statistical confidence of different audit strategies. As noted in Chapter 3, other states employ two main statistical audit strategies. Most states that require post-election audits use a fixed-percentage (FP) audit strategy, while a smaller but growing number use an adjustable-percentage (AP) or combined strategy. As noted in Chapters 3 and 4, there are also several audit methods, which can be categorized as either hand-to-eye count (HTEC) or machine-assisted (MA).

JLARC staff developed and applied a hypothetical audit approach to Virginia's current electoral environment. For comparative purposes, the approach was applied using both the FP and AP audit strategies, as well as the HTEC and MA audit methods.

HYPOTHETICAL AUDIT APPROACH AND ASSUMPTIONS

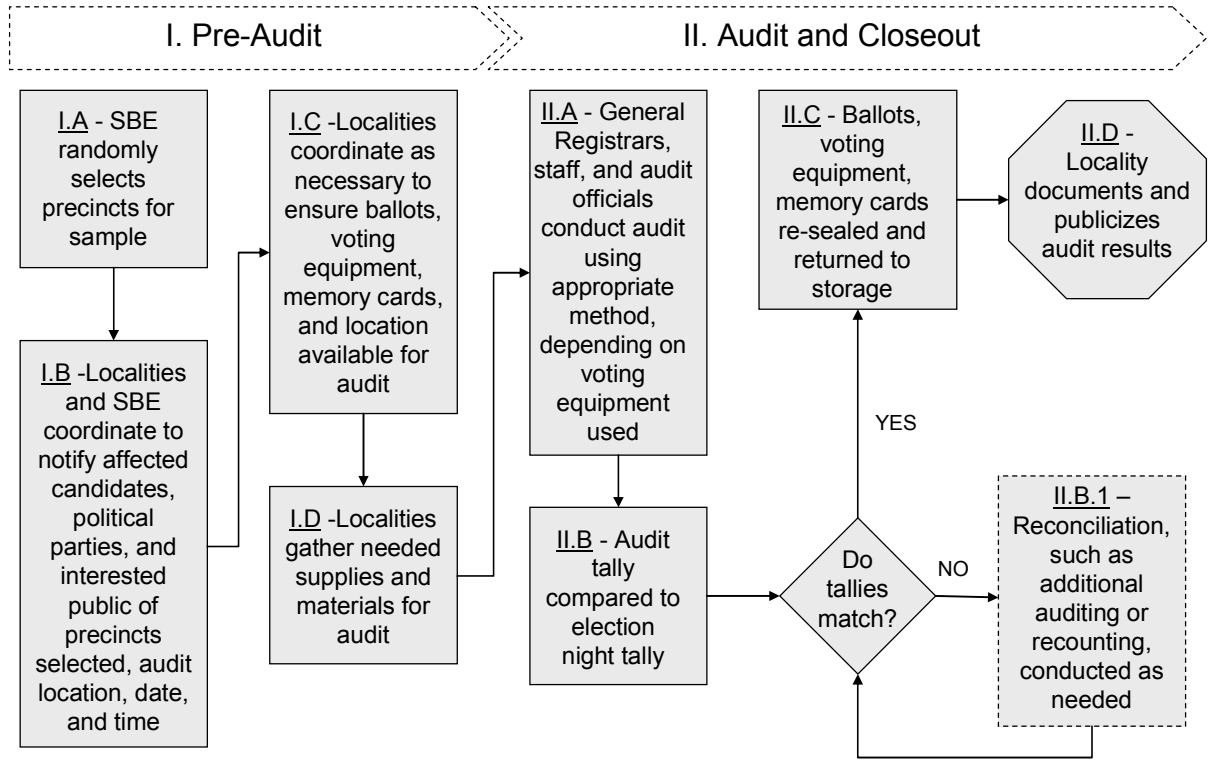
In order to provide reasonable time and expenditure estimates, JLARC staff compiled information about each of Virginia's localities. This information included whether the locality used direct recording equipment (DRE), optical scan (OS) machines, or a mix of both; the number of precincts in the locality; and the number of registered voters in each precinct. JLARC staff then developed a hypothetical audit approach and made a series of assumptions about how post-election audits could be implemented in Virginia. The approach and assumptions were then applied to the informa-

tion about each Virginia locality, resulting in information about the time, expenditures, and statistical considerations for various audit strategies and methods.

Hypothetical Audit Approach for Basis of Time and Expenditure Estimates

The hypothetical approach is based on JLARC staff research into other states' post-election audit approaches, interviews with and surveys of those knowledgeable about post-election audits, and information collected during Virginia's post-election pilot project. Whether a FP or AP audit strategy is employed, the post-election audit approach used by Virginia would likely consist of the same two main phases: pre-audit and audit and closeout (Figure 13). During the pre-audit phase, SBE would randomly select precincts at the local level to be included in the audit sample. Localities and SBE would then coordinate as necessary to notify affected candidates, political parties, and others who may be interested in observing the audit, of the audit details. Localities would then coordinate internally among the general registrar, electoral board, and clerk of the circuit court to ensure access to the key items needed for the audit, including ballots and voting equipment.

Figure 13: Hypothetical Approach for Post-election Audits



Source: JLARC staff analysis of other states' audit approaches, interviews and survey, and Virginia post-election audit pilot project.

In the pre-audit phase, each general registrar would also be responsible for determining how the audit would be staffed. At a minimum, there would likely be someone serving as an audit coordinator and two other people serving as audit officials. Staff with knowledge of the voting equipment being audited, the locality's voting equipment vendor, as well as administrative support staff may also need to participate in certain parts of the audit.

The audit and closeout phase would consist of conducting the audit itself, with the specific process, resources, and time required varying depending on what type of voting equipment the locality uses and what audit method is used. Once the counting is completed, the audit tally would then be compared to the election night tally. If the tallies are the same, then the locality would re-seal and return the ballots, voting equipment, and other materials to storage. However, if the tallies do not match, audit officials would attempt to reconcile the difference by re-examining and/or recounting their initial tally to try to find the reason for the discrepancy. Once the audit tallies match or the likely reason for the discrepancy is identified, the audit then would conclude with the locality documenting and publicizing the result of the audit.

Key Assumptions Used by JLARC Staff to Calculate Audit Time and Expenditure Estimates

There are several important assumptions about how post-election audits would be implemented in Virginia that impact how much time and money might be involved if audits were required. For each of the time and expenditure estimates that follow in this chapter, JLARC staff have made a series of baseline assumptions. In addition, variations from these baseline assumptions are also shown to illustrate their impact on the time and expenditure estimates. When possible, these assumptions are based on existing procedures and actual data about Virginia's localities. Three key assumptions are made in the baseline estimates:

- A machine-assisted audit method would be used. Though the majority of other states use an HTEC method and computer scientists express concern about auditing DRE memory cards, Virginia's current recount procedures require a MA method. When asked on the JLARC staff survey of Virginia general registrars, adopting the current recount procedures was the most frequently-cited way to conduct an audit on both DREs and OS machines. Consequently, JLARC staff have assumed the most likely method used for audits in Virginia would be the MA method.
- Many localities would require assistance from their voting equipment vendor to program their DRE and OS machines to

conduct a machine-assisted audit. MA audits would require each locality to prepare their voting equipment and/or computers to analyze memory cards from their DREs and/or re-accept OS ballots. Some localities in Virginia report currently having the capability to do this "in-house," while others report they would require assistance from their voting equipment vendor. According to the Brennan Center for Justice at New York University Law School, this need for vendor assistance is among the most significant factors that determines what a locality—and by extension the State collectively—would spend if audits were required. Where possible, JLARC staff used estimates made by localities of what they would pay their vendor for assistance in preparing for an audit.

- Localities would pay citizens to help conduct the audit of OS machines, but not DREs. The process of analyzing a DRE memory card is not time-consuming, and something that could be done by existing staff (or vendors) in most Virginia general registrar offices. However, either feeding ballots into an OS machine or hand-counting OS ballots—particularly in precincts with high numbers of voters or in multiple precincts—would likely require the assistance of other people to serve as audit officials. In these cases, the locality could use a subset of those who serve as election officials on election day, and pay them on a pro-rated basis for their work. Where possible, the actual amount that localities pay election officials was used in the estimates made by JLARC staff.

SAMPLE SIZE, STATISTICAL CONSIDERATIONS, TIME, AND EXPENDITURES IF VIRGINIA IMPLEMENTED A FIXED-PERCENTAGE AUDIT STRATEGY

A 2007 paper co-authored by the Brennan Center for Justice at New York University School of Law and the Samuelson Law, Technology, and Public Policy Clinic at the University of California, Berkeley School of Law provides a definition for a fixed-percentage (FP) post-election audit:

> Jurisdictions are required to randomly select a fixed percentage of precincts or machines to audit. All voter verifiable paper records for the selected precincts or machines are hand-counted and compared to the electronic tallies.

Fixed-Percentage Audit Features Stable Sample Size, but Is Not Intended to Provide Statistical Confidence About Election Outcome

The primary purpose of the FP audit strategy is to check the security, accuracy, and reliability of the voting equipment used on elec-

tion day. The FP audit strategy features a stable, constant sample size that does not vary based on the margin of victory. This strategy is not necessarily intended to provide a particular degree of statistical confidence that the election outcome was correct. As shown in Table 9, a FP audit of one percent of the State's precincts would result in a sample size of 135 precincts and an estimated 138,937 ballots. Each locality would be required to audit one precinct, and Fairfax County, which has more than 200 precincts, would be required to audit two precincts. An important consideration is that in most localities, one percent of precincts is far less than one precinct. As a result, in cases where one percent of precincts was less than one precinct, JLARC staff assumed that one full precinct would be audited. For example, Augusta County has 25 precincts and a one percent audit would call for auditing one-quarter of a precinct, which is not currently possible. The inability to audit a portion of a precinct means that four percent of the county's precincts would be audited when only one percent was necessary according to the sample strategy.

… in most localities, one percent of precincts is far less than one precinct.

The number of precincts and ballots included in the sample would increase as larger fixed-percentage sample sizes are chosen. However, once a fixed-percentage sample size is chosen, whether it is one, three, five, or some higher percentage, the number of precincts does not change from election to election. This stability in sample size facilitates planning at both the State and local levels for the time and expenditures that would be necessary if fixed-audits were required.

Table 9: Precincts and Ballots Included in Fixed-Percentage Audit of One, Three, and Five Percent of Precincts

Fixed-Percentage	# of Precincts in Sample	Estimated # of Ballots Included in Precincts Sampled
1	135	138,937
3	151	162,524
5	175	196,550

Note: Estimates assume (1) statewide voter turnout of 55percent among 4.97 million registered Virginia voters in 2,363 precincts (excluding central absentee precincts); (2) precinct for audit in each locality is chosen randomly after the election has occurred; (3) the chosen precinct has the average number of voters in a given precinct for the locality; and (4) in localities with fewer than 100 precincts, one entire precinct would be audited.

Source: JLARC staff analysis.

FP Strategy Could Take Each Locality, On Average, 5.5 to 6.2 Hours

If Virginia were to require FP audits, each locality could take, on average, slightly more than half a day to complete the pre-audit and audit and closeout phases. Using a baseline scenario that as-

sumes that both DREs and OS machines are subject to audit and that a MA method is used, it would take approximately 5.5 hours for an average locality to complete a one-percent audit (Table 10). It would take an average locality only slightly longer, 5.8 hours and 6.2 hours, to complete a three- and five-percent audit, respectively. As the audit sample size increases 200 percent from one percent to three percent, the audit time only increases about 13 percent. These small increases in average audit time even as the sample size increases can be explained by two factors:

- The dynamic noted above whereby one, three, and five percent is still well below a single precinct in many localities. Consequently, many localities still audit a single precinct as the sample size increases.
- The large role that the pre-audit activities play in the time of the total audit. In many cases, it could take longer to coordinate within the locality and secure access to the needed audit materials than it could to actually conduct the audit. This is especially true for localities using only DREs.

These averages mask a wide variation in the time it might take a small locality compared to a larger locality. For example, a large locality such as Virginia Beach would audit five precincts in a five-percent audit, which would take a single audit team an estimated 14.8 hours. A smaller locality such as Surry County would still audit one precinct in a five-percent audit, taking a single audit team about 2.4 hours.

If the HTEC method rather than a MA audit method were used, it would take slightly less time to conduct a one-percent audit. This dynamic occurs because time is saved with smaller samples by not having to prepare voting equipment to be used in the audit. Because of the large percentage of localities using DREs—which are therefore unaffected by using the HTEC rather than the MA method—even very large sample sizes take less time statewide when the HTEC method is used.

Table 10: Estimated Average Time Per Locality to Conduct Fixed-Percentage Audit Based on Various Assumptions

	Fixed-Percentage (Average Locality Audit Time in Hours)		
	1% Sample	*3% Sample*	*5% Sample*
Baseline Scenario[a]	5.5	5.8	6.2
OS Hand-to-eye Count	5.0	5.3	5.7

[a] Baseline scenario assumes (1) DRE and OS machines are both subject to audit; (2) MA rather than HTEC audit method is used to audit OS machines, and (3) localities with both DREs and OS machines conduct the audit of each type of equipment sequentially, rather than simultaneously.

Source: JLARC staff analysis.

FP Strategy Could Require Up to $148,000 in Expenditures

A one-percent audit could cost about $145,000 statewide, assuming that: both DREs and OS machines are subject to audit, a MA method is used, localities need to pay IT vendor fees, and localities with OS machines pay audit officials. A three-percent audit could cost about $146,000. A five-percent audit could cost just under $148,000.

Depending on the audit sample size and variations in the baseline assumptions, a FP audit could cost anywhere between about $9,000 and $148,000, statewide (Table 11). This wide range is driven less by the size of the audit sample and more by changes to the baseline assumptions. This is illustrated most clearly by the large drop in potential expenditures when no IT vendor fees are included. Removing these IT vendor support fees from the estimate significantly reduces the cost, and therefore cost per ballot, down to $0.06. This lower cost per ballot estimate that does not include IT vendor fees is more consistent with the cost per ballot figures reported by several other states highlighted in Chapter 3. This suggests that (1) these other state estimates do not include these IT vendor fees, and/or (2) the vendor fees are not relevant in other state audits using the HTEC method.

Using a HTEC method rather than a MA method would cost between $85,000 and $90,000. This is lower than the baseline scenario estimate because localities would not need to pay IT vendor fees to prepare to audit their OS machines. This would not affect, however, the localities that would still need IT vendor assistance to analyze their DRE memory cards.

The $145,267 in expenditures for a one-percent audit would be, on average, $1,084 for each of Virginia's 134 localities. However, actual expenditures for any given locality would vary depending on

Table 11: Estimated Total Statewide Expenditure Estimates for Fixed-Percentage Audit Based on Various Assumptions

	Fixed-Percentage					
	1% Sample		*3% Sample*		*5% Sample*	
	$	*$ / Ballot*	*$*	*$ / Ballot*	*$*	*$ / Ballot*
Baseline Scenario[a]	$145,267	$1.05	$146,252	$0.90	$147,928	$0.75
OS Hand-to-eye Count	85,756	0.62	87,235	0.54	89,404	0.45
No IT Vendor Fees	8,674	0.06	9,660	0.06	11,336	0.06

[a] Baseline scenario assumes (1) DRE and OS machines are both subject to audit; (2) MA rather than HTEC audit method is used to audit OS machines; (3) localities with both DREs and OS machines conduct the audit of each type of equipment sequentially rather than simultaneously; (4) localities with OS machines pay audit officials the equivalent of a half day of work per precinct counted calculated using a locality-reported average of the daily rate paid to election officials; and (5) localities without programming ability will pay their vendor a fee to program their equipment for the audit.

Source: JLARC staff analysis.

how many votes are cast in the precinct selected for audit, whether they must pay a vendor for IT support, and how much they paid those who serve on audit teams. Chesterfield County, for example, reported it might spend more than $7,500 to conduct an audit using the baseline scenario assumptions noted above. The vast majority of this would be IT vendor fees. Other localities, however, such as Roanoke County, reported that it would not have to pay IT vendor fees and would therefore spend less than $100 to pay an audit team to count a small number of ballots cast on an OS machine.

The median annual budget reported by Virginia general registrars to JLARC staff was approximately $138,000. Budgets in smaller localities are considerably lower, while budgets in larger localities are considerably higher. Consequently, audit expenditures as a percentage of locality's audit expenditures on elections would vary widely as well. For example, a large locality such as Chesterfield County reported a budget of approximately $900,000, and the expenditures noted above for a one-percent fixed audit would be about 0.8 percent of its annual budget. A smaller locality such as Tazewell County reported a budget of $128,034, and could spend more than $5,000 (again, the bulk of which would be IT fees), or 3.9 percent of its budget.

With these local and statewide estimates, it is important to again emphasize that these are projections based on multiple assumptions. Because of this, the actual cost of an audit statewide and for a particular locality could vary from the estimates provided.

SAMPLE SIZE, STATISTICAL CONSIDERATIONS, TIME, AND EXPENDITURES IF VIRGINIA IMPLEMENTED AN ADJUSTABLE-PERCENTAGE AUDIT STRATEGY

The same 2007 paper used to define the FP strategy above also defines the adjustable-percentage approach:

> This model requires jurisdictions to determine the percentage of precincts or machines to audit based on the size of the margin of victory between the two leading candidates in a race. The smaller the margin of victory, the larger the percentage of precincts or machines to audit.

Adjustable Audit Features Variable Sample Size Designed to Provide High Degree of Statistical Confidence About Election Outcome

The AP audit strategy requires that the margin of victory be known to select a sample size that will provide a 99 percent chance that the audit did not miss something that could have changed the

election results. Elections with smaller margins of victory require larger sample sizes, while elections with larger margins of victory require smaller sample sizes (Table 12).

The variable nature of the AP sample size, while necessary to achieve a desired level of statistical confidence, makes the AP audit strategy more difficult to plan than the FP audit. This difficulty stems, in part, from the adjustable strategy requiring the margin of victory to be known prior to determining the sample size and randomly selecting precincts to be included. This means prior to the election, localities do not know (1) whether they will be included in the sample and (2) how many precincts, if any, in their locality will be audited. In contrast, the FP audit does not rely on the margin of victory; therefore, each locality would know that it would be required to audit at least one precinct, and only have to wait until after the sample selection to know exactly which precinct(s) had been selected. This would especially impact the timing of collaborating with the clerk of the circuit court in each locality on access to the ballots, securing space to conduct the audit, and identifying people to serve on audit teams.

Another planning difficulty is related to the magnitude of resources needed to conduct the audit. While past election results can be averaged to project a likely future margin of victory average across multiple elections, the margin of victory in any given future election could be either in line with the historical average, very small, or very large. This means that the time and expenditures required to implement an AP strategy—again because its sample

Table 12: Precincts and Ballots Audited in Statewide Races Using an AP Strategy Designed to Achieve 99 Percent Confidence

Margin of Victory [a]	# of Precincts in Sample [b]	Estimated # of Ballots Included in Precincts Sampled
0.25%	631	1,327,420
0.50	339	713,146
0.75	231	485,949
1.0	175	368,143
2.0	88	185,124
3.0	58	122,013
5.0	34	71,525
10.0	16	33,659
15.0	10	21,037
20.0	7	14,726
25.0	5	10,518

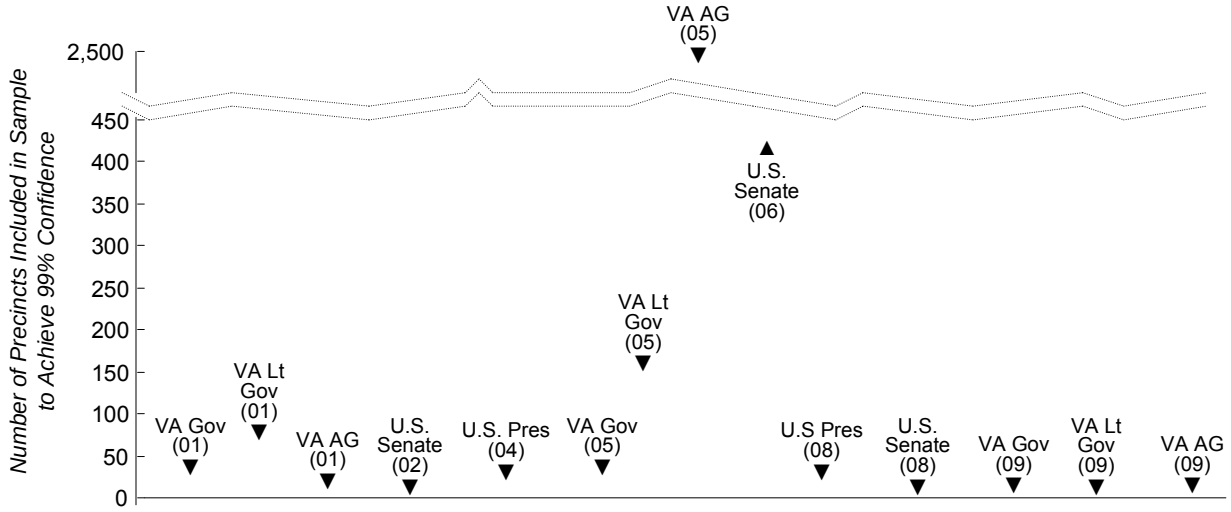
[a] When the margin of victory between the two candidates is equal to or less than one percentage point, the *Code of Virginia* §24.2-800 allows the apparently unsuccessful candidate to petition for a full recount.
[b] Number of precincts shown is the minimum number of precincts required for 99 percent statistical confidence.

Source: JLARC staff analysis.

size is determined by the margin of victory—can vary substantially from election to election.

To illustrate how the number of precincts audited under an AP strategy could vary, JLARC staff retroactively applied it to the 14 statewide elections held in Virginia since 2001. As shown in Figure 15, the sample size would have ranged from one precinct (though it is questionable whether this would have been worth the time required, and a larger number of precincts could have been included) in the 2002 U.S. Senate Race all the way to 2,362 precincts in the 2005 Virginia Attorney General (AG) race. Simply stated, the variable sample size of the AP strategy is statistically desirable, but potentially problematic from a planning and resource perspective.

Figure 15: Sample Size Variability If Adjustable Percentage Audit Had Been in Place for Statewide Elections Since 2001



Source: JLARC staff analysis of SBE data.

AP Strategy Is Likely, on Average, to Require Less Time and Cost Less Than FP Strategy

As noted above, the sample size required under the AP for any given election could vary widely. By extension, the time and expenditures required for the AP could be well below—but also much more—than the FP strategy. In close elections, the AP strategy could require almost the same amount of time and cost associated with a full recount of the vote (though probably lower because the court system would not be involved to the same degree).

On average, however, the AP strategy appears likely to require less time and lower expenditures than the FP strategy. JLARC staff calculated the average margin of victory from the same 14 statewide elections since 2001 used above. This 13.7 percent mar-

gin of victory was then used to determine the sample size required under the AP statistical formula. To achieve 99 percent confidence in the result of a post-election audit of a race with a 13.7 percentage point margin of victory, 11 randomly chosen precincts would need to be audited. Using the same baseline assumptions as were used for the FP audit, these 11 localities would take, on average, 4.8 hours to complete the pre-audit and audit and closeout phases of the hypothetical audit approach. The time required to conduct the audit changes very little if the OS machines are audited using a HTEC rather than a MA method (Table 13). This compares to the 5.5 hours estimated for a one-percent FP audit.

The AP strategy could cost the 11 localities included in the sample up to $16,000 in total, using the same baseline assumptions (Table 14). This is less than the estimated cost of $145,267 for a one percent FP audit. The same factors that affect the expenditures for the FP audits discussed above are relevant for the AP audit. However, the potential variability in costs would be driven not only by the margin of victory in the race, but also by which localities are randomly chosen as part of the example. The dynamic is illustrated by the different potential expenditures among the 11 localities randomly selected for inclusion in this AP audit sample. One precinct randomly selected was in Lee County, which reported it would require IT vendor support to conduct an audit, costing the county $4,000. Another precinct was in Chesapeake, which reported it would not require IT vendor support to conduct an audit.

Table 13: Time Estimates for Adjustable Strategy Audit in an Average Virginia Election

	Average Locality Time (in hours)
Baseline Scenario[a]	4.8
OS Hand-to-eye Count	5.0

Note: Estimates assume (1) statewide voter turnout of 55 percent among 4.97 million registered Virginia voters in 2,363 precincts (excluding central absentee precincts); (2) precinct for audit in each locality is chosen randomly after the election has occurred; (3) precincts selected for the sample were determined using a random number generator; (4) DRE and OS machines are both subject to audit; and (5) localities with both DREs and OS machines conduct the audit of each type of equipment sequentially rather than simultaneously.

[a] Baseline scenario assumes that an MA rather than a HTEC method is used to audit the OS machines.

Source: JLARC staff analysis.

Table 14: Cost Estimates for Adjustable Strategy Audit in an Average Virginia Election

	$	*$ / Ballot*
Baseline Scenario [a]	$15,822	$1.09
OS Hand-to-eye Count	11,822	0.81
No IT Vendor Fees	822	0.06

Note: Estimates assume (1) statewide voter turnout of 55 percent among 4.97 million registered Virginia voters in 2,363 precincts; (2) precinct for audit in each locality is chosen randomly after the election has occurred; (3) precincts selected for the sample were determined using a random number generator; (4) DRE and OS machines are both subject to audit; (5) localities with both DREs and OS machines conduct the audit of each type of equipment sequentially rather than simultaneously; (6) audit officials are paid the equivalent of a half day of work per precinct counted; and (7) localities without programming ability will pay their vendor a fee to program their equipment for the audit.

[a] Baseline scenario assumes that a MA rather than a HTEC method is used to audit the OS machines.

Source: JLARC staff analysis.

Chapter 6

Potential Role of Post-election Audits in Virginia

In Summary

Conducting post-election audits would result in benefits, such as enhanced election transparency and providing insight into the security, accuracy, and reliability of voting equipment. Achieving these benefits would require Virginia—primarily localities—to spend varying amounts of time and resources depending on which audit strategy is employed. These benefits and costs need to be considered in the context of several important implementation considerations that specifically relate to Virginia's environment. These considerations include the prevalence of direct recording equipment (DRE) used by localities, which do not have a paper trail and therefore can only be audited by analyzing the memory cards used by the machines. Computer scientists indicate analyzing these memory cards has limited usefulness because the process, unlike an audit using a paper ballot, is not an independent check. In addition, some of the benefits of post-election audits can likely be achieved in ways other than requiring an ongoing, large-scale audit program.

JLARC staff were not directed to recommend whether Virginia should require post-election audits. However, a summary of information gained in this study can provide insight into the benefits and costs and the potential role that post-election audits could play in Virginia.

BENEFITS AND COSTS OF REQUIRING POST-ELECTION AUDITS

Implementing post-election audits likely would result in some benefits for Virginia. Realizing these benefits would require incurring some costs, primarily time and expenditures by Virginia's localities. Balancing these benefits and costs is an important part of understanding the potential role that post-election audits could play in Virginia.

Various Audit Purposes Provide Framework to Assess Potential Benefits of Post-election Audits

As noted in Chapter 3, other states report that they conduct post-election audits to achieve a variety of purposes. These purposes include (1) enhancing election transparency; (2) providing insight into voting equipment security, accuracy, and reliability; (3) identifying lessons learned to improve the electoral process; and (4) validating the election outcome. These purposes can serve as a

framework to discuss the potential benefits of requiring either a fixed-percentage (FP) or adjustable-percentage (AP) audit.

When assessed on a relative basis against each other, the FP and AP audit strategies would achieve the above four benefits to differing degrees. A one-percent FP audit would, in most cases, provide a high degree of election transparency and insight into voting equipment security, accuracy, and reliability. It would also in most cases provide more opportunities to identify lessons learned than the AP strategy. This is essentially because, on average, the FP strategy would require at least one precinct to be audited in each of the State's 134 localities. This means that all voting equipment used by the State would be subject to audit and that interested individuals would have opportunities in all parts of the State to observe audits when they occur. The AP audit strategy would, on average, result in fewer precincts being audited. Because of this smaller sample size and because all voting equipment models would likely not be audited, the AP strategy would achieve the first three benefits noted above to a lesser degree.

Alternatively, the AP strategy would provide the benefit of validating the election outcome to a high degree when compared to the FP strategy. As discussed in Chapter 5, the sample size for the AP audit strategy is calculated based on what would be necessary to achieve 99 percent statistical confidence in the election outcome. In contrast, the FP strategy sample size remains the same regardless of the margin of victory.

… validating the election outcome may be less necessary considering that most Virginia elections are not close and there are recount provisions.

Achieving this fourth benefit of validating the election outcome may be less necessary, however, given two aspects of Virginia's electoral environment. First, as noted in Chapter 1, §24.2-800 of the *Code of Virginia* stipulates that when the difference between the apparent winner and defeated candidate is not more than one percent, the defeated candidate may appeal for a recount. This statutory provision has come in to play, for example, in 2009 in the 21st House of Delegates district race, in 2008 in the 5th Congressional district race, and in 2005 in the Virginia Attorney General's race. In each of these recounts and others, the recount did not change the election outcome. A few other recent elections have also been close, such as the 2006 race for one of Virginia's U.S. Senate seats, but the losing candidate did not request a recount.

Second, most elections in Virginia are not close (Table 15). In fact, only 52, or about 13 percent, of the 416 elections analyzed by JLARC staff had a margin of victory closer than 10 percent. Only seven of those were within a one-percent margin. Taken together, the existence of a recount statute and the historical pattern of most elections not being close may reduce the need to further validate election outcomes in Virginia.

Table 15: Margins of Victory in Recent Virginia Races

			# of Races With Margin of Victory…			
	Year	*# of Races*	*<10%*	*5%-2%*	*2%-1%*	*<1%*
U.S. President	2008	1	1	0	0	0
	2004	1	1	0	0	0
U.S. Senate	2008	1	0	0	0	0
	2006	1	0	0	0	1
	2002	1	0	0	0	0
Virginia statewide offices (Gov., Lt. Gov., Att. Gen.)	2009	3	0	0	0	0
	2005	3	2	0	1	1
	2001	3	2	1	0	0
U.S. House of Representatives	2008	11	2	1	0	1
	2006	11	1	1	0	0
Virginia Senate	2007	40	8	1	4	1
	2003	40	3	0	0	0
Virginia House of Delegates	2009	100	12	5	6	2
	2007	100	10	4	1	0
	2005	100	10	2	1	1
Totals		*416*	*52*	*15*	*13*	*7*

Source: JLARC staff analysis of SBE data.

Potential Audit Benefits Compared to Potential Audit Costs

To achieve the four benefits discussed above would require time and expenditures—primarily on the part of Virginia's localities (Table 16). Depending on whether an FP or AP strategy is employed, it could take localities, on average, slightly more than half a day to complete the audit process. Expenditures for a one-percent FP audit would be about $145,000, while expenditures for an AP strategy could average less than $16,000, but in close elections be almost as much as a full recount of all precincts.

Two key themes emerge from an analysis of the benefits and costs of post-election audits:

- Enhanced election transparency; insight into voting equipment security, accuracy, and reliability; and lessons learned can be achieved for about a half day of time and just more than $1,000 per locality, on average.
- Validating the election outcome can be achieved for lower time and expenditures that would, on average, impact fewer localities. However, achieving this benefit also comes with the risk of more time and expenditures in the event of a close election.

Table 16: Potential Benefits and Costs If Virginia Were to Require Post-election Audits

Audit Strategy	Potential Benefits				Potential Costs	
	(1) Election Transparency	*(2) Security, Accuracy, Reliability*	*(3) Lessons Learned*	*(4) Validate Election Outcome*	*Time*	*$*
1% Fixed - Percentage	●	●	●	◑	5.5 hours / locality	$145,267
Adjustable - Percentage[a]	◑	◑	◑	●	Range of 4.8 hours / locality[b] to same as full recount	Range of $15,822[b] to same as full recount

Legend for Scale of Potential Benefit ● High ◑ Medium ○ Low

[a] Assumes a margin of victory that is the average of a sample of races in Virginia since 2001, which is 13.7 percent.
[b] Would involve 11 localities with the margin of victory noted above.

Source: JLARC staff analysis.

A less quantifiable, but still important, final consideration is how requiring post-election audits would be done within the State's current statutory and procedural framework. Depending on how they are structured and when they are conducted, requiring post-election audits would necessitate a number of changes to the *Code of Virginia*. The most significant of these changes depends on when the State chooses to conduct the audits. Conducting audits prior to local or SBE certification could require expanding the time given to localities to canvass and certify election results, as well as the time given to SBE to certify results. As noted in Chapter 3, the majority of other states that require audits conduct them prior to election certification.

When asked, however, Virginia general registrars had mixed opinions about when audits should be required. About a third thought they could be done after the recount deadline, while either 35 or 40 percent (depending on whether they use OS machines or DREs) thought they could be done after certification, but before the recount deadline. About one-quarter thought they should be done before certification.

More information about other potential changes required to the *Code of Virginia* is provided in Appendix D.

KEY IMPLEMENTATION CONSIDERATIONS OF REQUIRING POST-ELECTION AUDITS

Beyond the benefits and costs of post-election audits discussed above, some additional implementation considerations are relevant

when assessing the potential role that audits could play in Virginia. These include the diversity of Virginia's voting equipment, that some benefits of audits could be achieved without requiring all localities to participate in an ongoing audit program, and that most Virginia general registrars are strongly against requiring localities to conduct audits. While none of these considerations are alone reasons to not require post-election audits, they collectively suggest that it may not be prudent to require an ongoing, large-scale audit program at this time.

Virginia's Mixed Voting Equipment Environment Complicates Post-election Audit Implementation

Despite the statutory prohibition against purchasing new DREs, they are still used by many localities. Only five localities use only OS machines (other than for disabled or absentee voters). The fact that Virginia's DREs have no paper trail, unlike the OS ballots, means that localities auditing DREs would in most cases use the DRE memory card from the election to re-run the election results.

The fundamental difference between OS machines and DREs raises two potential complications.

This fundamental difference between OS machines and DREs raises two potential complications. First, some computer scientists and interest groups have expressed skepticism about the value of re-running results from DRE memory cards. Although this is the typical approach used when conducting an audit or recount, computer scientists and interest groups place less faith in the process than auditing paper ballots from OS machines. Second, in nearly all cases, the 45 localities that use only DREs would spend far more time in the audit set-up phase than they would conducting the audit itself. Furthermore, the localities among these 45 that do not have the capabilities in-house to audit the memory cards would need to pay additional IT vendor fees.

The current prevalence of DREs in Virginia suggests it may not be prudent to require all localities to participate in a large-scale, ongoing post-election audit program. As localities' current DREs are retired and replaced with OS machines, this complication disappears. As noted in Chapter 2, DREs will be prevalent across Virginia for at least another five years based on locality's current plans.

Audit Benefits Can Be Achieved Without an Ongoing Program Requiring All Localities to Conduct Audits in Every Election

Most other states that require audits conduct them on at least one contest in every statewide election. However, even the relatively small-scale pilot audit project recently conducted in Virginia provided some of the intended benefits of larger, more formalized post-election audit programs. For example,

- The observers who attended the audits in person, and other interested individuals who are informed of the audit results, benefit from the enhanced transparency of the elections that were audited.
- The pilot audit results, showing a difference of 0.21 percent between the election day and audit totals, provide some insight into the security, accuracy, and reliability of the four models of OS machine audited.
- Lessons that could potentially improve the electoral process—in particular the ability to examine ballots not completed according to the instructions given—were learned and resulted in a recommendation for SBE to assess the issue further.

This suggests that for those interested in achieving the benefits of audits, SBE and localities could coordinate to conduct additional audits under the existing pilot program statute. Alternatively, SBE could approve post-election audit procedures and the General Assembly could amend the *Code of Virginia* to give localities explicit permission to conduct audits if they wish. Voters' rights organizations and some in academia suggest other approaches that would provide insight into the accuracy of voting equipment without the time and effort involved in a large-scale required audit program. These approaches include candidate-requested audits of small samples of ballots when results seem unusual, or audits of small batches of ballots within a precinct, rather than entire precincts.

Most General Registrars Would Likely Be Strongly Against Requiring All Localities to Conduct Audits Using Local Resources

In response to the JLARC staff survey of Virginia general registrars, the majority of registrars reported they were either somewhat or not very familiar with post-election audits. Nevertheless, these would be the individuals most responsible for implementing post-election audits if they were required by the State. When asked, Virginia registrars were at best lukewarm to the idea of having an additional requirement for post-election audits. Only 11 percent believed audits should be required, mostly if the State paid for the audits or split the cost with localities. Forty-two percent reported that localities should be authorized to conduct post-election audits at their discretion, but not required to do so. Another 37 percent reported that post-election audits should not be required.

Over 80 percent of registrars reported that they believe audits might not be a good idea for several reasons, including their beliefs that: (1) Virginia's voting equipment is already secure, accurate, and reliable; (2) Virginia's recount and contest provisions ade-

quately address ensuring the correct person was elected based on the actual vote; and (3) there are better uses of resources to address concerns. In addition, when shown a list of nine options (such as allowing more time for the local canvass or more effective training) that would potentially improve the security, accuracy, and reliability of elections, requiring post-election audits was selected least frequently—by only eight registrars.

In most cases, audits would take about a half-day of time for a typical general registrar and some SBE staff time. However, depending on how audits are implemented, it could require a varying amount of expenditures and time per locality. This extra demand on localities' time, particularly if audits are required prior to certification, would occur shortly after staff had worked long hours preparing for and holding the election. In addition, these expenditures, particularly for localities that must pay IT vendor fees, could be a considerable percentage—perhaps up to five percent—of their operating budgets. When asked, about two-thirds of Virginia general registrars thought that if audits are required, they should be State funded and locally executed. Most of the remaining registrars thought they should be both State funded and State executed.

These survey findings suggest that collectively Virginia general registrars are opposed to requiring localities to conduct audits, especially if local resources are required. Though this is not sufficient reason alone to not require audits, it represents a challenge when considering successful implementation of a large, ongoing post-election audit program.

Appendix A Study Mandate

SENATE JOINT RESOLUTION NO. 328
Directing the Joint Legislative Audit and Review Commission to study postelection audits of voting equipment. Report.

Agreed to by the Senate, February 26, 2009
Agreed to by the House of Delegates, February 26, 2009

WHEREAS, Virginia has witnessed several close elections in recent years; and
WHEREAS, nineteen states conduct some form of postelection audit to confirm the integrity and accuracy of voting systems, and legislation proposing some form of postelection audit for the Commonwealth has come before the General Assembly each of the last three sessions; and
WHEREAS, the General Assembly added § 24.2-671.1 to the Code of Virginia in 2008 to authorize the State Board of Elections to provide for pilot programs for audits of optical scan tabulators in localities agreeing to participate; and
WHEREAS, there are multiple technical, financial, and legal issues concerning post election audits that are difficult to address during a legislative session; and
WHEREAS, a careful analysis of postelection audit options will serve to ensure the integrity of elections, voter confidence, and the wise investment of public resources; now, therefore, be it

RESOLVED by the Senate, the House of Delegates concurring, That the Joint Legislative Audit and Review Commission be directed to study postelection audits of voting equipment. In conducting its study, the Joint Legislative Audit and Review Commission shall (i) review alternative procedures and processes for postelection audits; (ii) examine the data, procedures, results, and conclusions of the pilot audit undertaken pursuant to § 24.2-671.1; (iii) estimate the time requirements and costs of postelection audits; (iv) review the experience of postelection audits in other states, (v) consider the statistical confidence of different audit strategies; and (vi) consider the changes that would be required in the Code and procedures for different audit strategies to be effective. In conducting its deliberations, the Joint Legislative Audit and Review Commission shall provide for participation by representatives of the state Democratic Party, the state Republican Party, and the Virginia Electoral Board Association, as well as experts in statistical analysis and election audits.

Technical assistance shall be provided by the State Board of Elections and the Virginia Information Technologies Agency. All agencies of the Commonwealth shall provide assistance to the Joint Legislative Audit and Review Commission for this study, upon request.

The Joint Legislative Audit and Review Commission shall complete its meetings for the first year by November 30, 2009, and for the second year by November 30, 2010, and the chairman shall submit to the Division of Legislative Automated Systems an executive summary of its findings and recommendations no later than the first day of the next Regular Session of the General Assembly for each year. Each executive summary shall state whether the Joint Legislative Audit and Review Commission intends to submit to the General Assembly and the Governor a report of its findings and recommendations for publication as a House or Senate document. The executive summaries and reports shall be submitted as provided in the procedures of the Division of Legislative Automated Systems for the processing of legislative documents and reports and shall be posted on the General Assembly's Website.

Appendix B

Research Activities and Methods

JLARC staff conducted four major research activities to address the study mandate:

- Facilitated pilot post-election audits in four Virginia localities;
- Administered surveys of Virginia general registrars and other states about post-election audits;
- Conducted interviews with State Board of Elections (SBE) staff, general registrars, electoral board members, computer scientists, and other states that conduct post-election audits; and
- Reviewed academic literature, reports from other states, and the *Code of Virginia*.

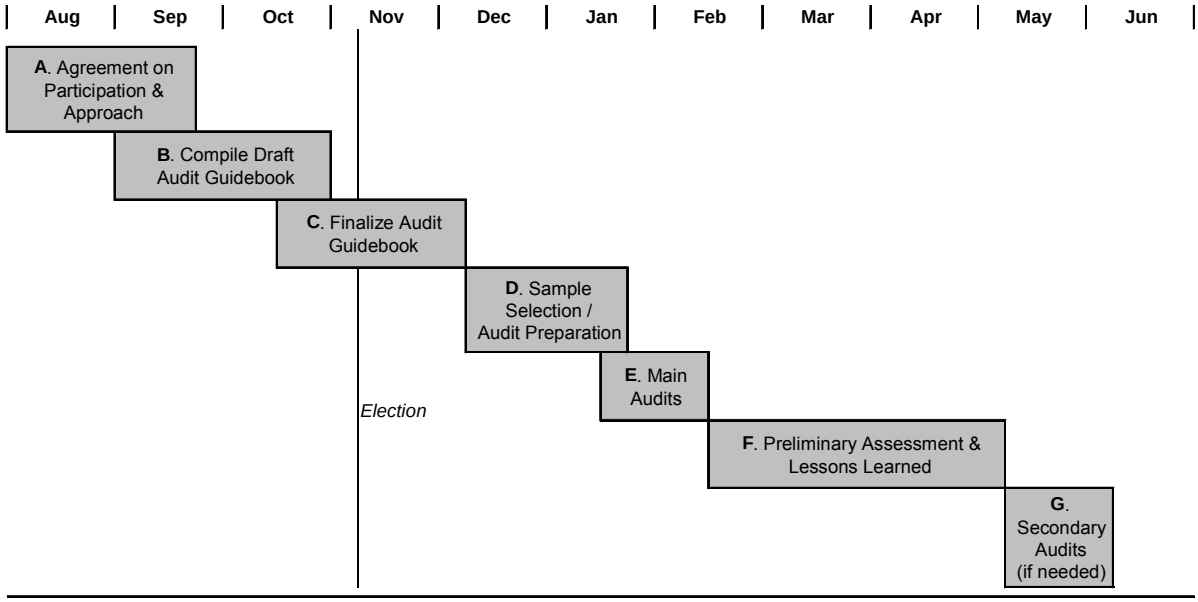
PILOT POST-ELECTION AUDITS IN FOUR VIRGINIA LOCALITIES

SJR 328 directed JLARC staff to "examine the data, procedures, results, and conclusions of the pilot audit undertaken pursuant to §24.2-671.1." However, when JLARC staff began planning for this study, no planning for the audit had been conducted. As a result, JLARC staff worked with SBE, the Virginia Electoral Board Association (VEBA), and the Voter Registrar's Association of Virginia (VRAV) to begin the process of identifying localities willing to volunteer to participate. In order to participate, the locality needed to at least partly use optical scan machines so that paper ballots were available to audit. The process resulted in the City of Charlottesville, and Page, Chesterfield, and Fairfax Counties volunteering.

Agreement on General Approach for Pilot Audits

After securing participation from the four localities, JLARC staff drafted a discussion document that articulated a general approach for the pilot audits consisting of the process steps and timeframes shown in Figure B-1. This discussion document was provided to SBE staff, the electoral board and general registrar in each of the four localities, the Democratic and Republican Parties of Virginia, and Virginia Verified Voting. After several rounds of feedback and meetings with various participants on the proposed approach, JLARC staff then began selecting the races and precincts included

Figure B-1: General Approach and Timeframes for Post-election Audits



Note: The main audits took place in February and March 2010, later than the original timeframe illustrated in this graphic. The timeframe was pushed back primarily due to inclement weather.

Source: JLARC staff, 2009.

in the audit sample, and drafting more specific audit guidebooks, instructions, and forms that would be used in each locality.

Draft and Final Audit Guidebook Development

After securing general agreement on a high-level audit approach, JLARC staff began developing a draft audit guidebook for use in each locality. The basis for the draft audit guidebook was primarily any existing SBE policy for recounts in Virginia and information collected by JLARC staff about other state's approaches to post-election audits. To collect information about various audit methods, the guidebooks were written to require variations on the hand-to-eye counting audit method used primarily by other states, and the machine-assisted audit method currently used in Virginia for recounts.

Audit participants commented on various aspects of the draft audit guidebook. These comments were incorporated by JLARC staff and reflected in the final audit guidebook. The final audit guidebook also included specific instructions and data capture forms that would be used at each of the four audits.

Audit Sample Selection

The statute that authorizes the pilot post-election audits, *Code of Virginia* §24.2-671.1, requires that every race on the ballot audited have a margin of victory greater than ten percentage points. This requirement prevented JLARC staff from using any probability sample design, such as simple random sampling or stratified random sampling. Consequently, the sample size and selection process became less important from a statistical perspective. Rather, the sample size and races to be included were chosen based on the statutory requirements and the time and resources that would be available to conduct each audit. Decision rules used by JLARC staff to select the races and precincts for audit included:

- No race on the ballot could have a margin of victory less than or equal to ten percentage points at the precinct, county, and state levels (if applicable).
- Precincts with the largest margins of victory in the selected race would be prioritized for selection.
- Precincts with 1,500 or fewer ballots cast would be prioritized for selection.
- The selected race should not present an appearance of a conflict of interest, such as a race involving a JLARC member or a race involving a candidate who has previously advocated for post-election audits.
- The race selected should not involve a substantial transition process for the victor, in particular the Governor's race.

Table B-1 shows the precincts and races selected for the pilot post-election audits based on the decision rules presented above. In both Page and Chesterfield Counties, JLARC staff determined that the race for Attorney General from the November 2009 General

Table B-1: Races and Precincts Selected for the Pilot Post-election Audits

Locality	Race Selected	Precincts Selected	Votes Audited	% of Locality's Votes for This Race Audited
Page County	Attorney General, 11/2009	401 – Newport 501—Shenandoah	1,959	26.9%
City of Charlottesville	Governor, Democratic Primary, 6/2009	CAP – Central Absentee	41	1.3
Fairfax County	House of Delegates District 45, 11/2009	408 – Mt. Eagle 608 – Kirkside 621 – Grosvenor	1,860	40.6
Chesterfield County	Attorney General, 11/2009	307 – Cosby 511 – Black Heath	2,442	2.7

Source: JLARC staff analysis of elections results data from the Virginia State Board of Elections.

Election would be used for the pilot audits. After eliminating the Governor's race from consideration (due to the potential transition involved for the Governor-Elect), the Attorney General's race had the largest margin of victory of the two other statewide races. In Chesterfield County, JLARC staff eliminated from consideration any precincts with over 1,500 ballots cast and any precincts in House District 66 (represented by Delegate Cox, a JLARC member). In Page County, JLARC staff selected the two precincts with the largest margins of victories in the Attorney General's race.

In Charlottesville, JLARC staff selected the Governor nominee race from the June 2009 democratic primary for the pilot audit. JLARC staff determined that the results of the November 2009 general election could not be used for the pilot post-election audit because a local race on that ballot had a margin of victory under ten percentage points. JLARC staff, therefore, determined that the results of the June 2009 Democratic primary would be used for the post-election audits in Charlottesville. It was subsequently determined that optical scan machines were only used in the central absentee precinct during the primaries, consequently it was the only precinct audited.

JLARC staff selected the House of Delegates District 45 race for the pilot post-election audit in Fairfax County. JLARC staff did not use any of the three statewide races from the November 2009 general election because each of these races had a margin of victory less than 10 percentage points at the county level. JLARC staff then considered the House of Delegates races in Fairfax County. JLARC staff sorted these races based on the races' margins of victories. Then JLARC staff analyzed precinct-level results for each of these races to find precincts that had margins of victories greater than 10 percentage points for all of their races. Three House Districts in Fairfax County had races with larger margins of victory than the race in House District 45; however, two of those races did not have three precincts where all the races on the precinct's ballot had margins of victory greater than ten percentage points, and the third district was won by Delegate Hugo who had previously introduced legislation regarding post-election audits, which could present a minimal appearance of a conflict of interest.

Audit Preparation, Including Audit Notification and SBE Approval

JLARC staff continued to prepare for the audits in each locality. These preparations included working with the Clerk of the Circuit Court in each locality on securing access to the ballots and a location to conduct the audit. Additionally, consistent with statutory requirements, JLARC staff sent written notifications to each candidate on the ballot in precincts selected for audits, local political parties, and the Democratic and Republican Parties of Virginia.

JLARC staff also posted information about the pilot audits on its website. The information included the audit time and location and race selected for audit in each of the four localities.

On January 15, 2010, SBE approved the proposed approach for the pilot post-election audits at a public meeting in the General Assembly Building. After SBE approval, several audits were rescheduled due to inclement weather. The revised audit dates and times were posted on the JLARC website, and individuals interested in observing the audit who had contacted JLARC staff for information were also notified of the changes.

Appendix C includes detailed information about the results of each of the four pilot audits.

SURVEYS OF VIRGINIA GENERAL REGISTRARS AND OTHER STATES ABOUT POST-ELECTION AUDITS

JLARC staff administered two surveys targeting (1) election staff in other states, and (2) Virginia general registrars. Surveys were designed to supplement the information gathered through the pilot post-election audits, structured interviews, and literature reviews.

Survey of Other States' Election Staff

JLARC staff surveyed election staff in other states to gather information about their voting system and their approach, if any, to conducting post-election audits. JLARC staff contacted the National Association of State Election Directors (NASED), and requested that they distribute a link to an online survey to their members. Survey topics included

- voting equipment used in the state;
- existence of statutory requirements for post-election audits;
- statistical strategies used to determine audit sample sizes;
- audit counting methods and timing of audit implementation within the electoral process;
- audit results and the usefulness of audits to achieve various purposes; and
- recommendations for designing a post-election audit program.

JLARC staff received 25 responses from other states and the District of Columbia.

Survey of Virginia General Registrars

JLARC staff surveyed Virginia's 134 general registrars to collect information about the electoral environment in their individual localities and their opinions regarding post-election audits. The VRAV and VEBA helped JLARC staff inform general registrars about the survey. JLARC staff sent a link to the on-line survey via e-mail to each general registrar. Survey topics included

- office budget and resources;
- voting equipment used in their locality and an assessment of its accuracy, reliability, and security;
- opinion regarding the necessity of post-election audits;
- recommendations regarding how post-election audits could be implemented; and
- opinions regarding the most effective and efficient ways to improve the electoral process.

JLARC staff received 110 responses from the State's general registrars—for a response rate of 82 percent.

INTERVIEWS WITH VARIOUS INDIVIDUALS AND ENTITIES ABOUT POST-ELECTION AUDITS

JLARC staff conducted a variety of interviews with personnel from SBE, Virginia general registrars and their staffs, Virginia electoral board members, representatives of voting integrity groups, computer scientists and academics with expertise in voting equipment and post-election audits, and election personnel in other states. These interviews covered a variety of topics including the broader electoral environment, voting equipment, and post-election audits.

REVIEWS OF LITERATURE, REPORTS, AND THE *CODE OF VIRGINIA*

JLARC staff reviewed numerous documents and studies to supplement and validate findings from interviews, the pilot post-election audits, and surveys. A review of the literature was conducted regarding the

- statistical strategies used to design post-election audits;
- various counting methods used to conduct post-election audits;
- performance of voting equipment; and
- assessments of the role that post-election audits and voting equipment play in the broader electoral environment.

Approximately half of states have conducted at least one post-election audit at some point in the past five to ten years, and some of these states have published reports on their methods and findings. JLARC staff reviewed this documentation from other states. States producing this documentation reviewed by JLARC staff include North Carolina, Georgia, New Mexico, Minnesota, and Connecticut.

JLARC staff also reviewed documentation other states produced regarding voting equipment. Some states have conducted studies on the accuracy, reliability, and security of the voting equipment used in their states. JLARC staff reviewed voting equipment studies conducted by Maryland, California, Ohio, and Florida.

Finally, JLARC staff reviewed the *Code of Virginia* and SBE policies related to election administration, recounts, and post-election audits.

Appendix C

Detailed Information on Pilot Post-election Audits

Section 24.2-671.1 of the *Code of Virginia* authorizes the State Board of Elections (SBE) to provide for pilot programs for audits of optical scan machines. The study mandate directs JLARC staff to examine the data, procedures, results, and conclusions of the pilot audit undertaken pursuant to §24.2-671.1. Consequently, JLARC staff worked with SBE staff, and general registrars, electoral boards, and clerks of the circuit court in four localities to develop and implement audits under this pilot program statute. The audits occurred during February and March 2010 and had two primary objectives:

1. To determine the difference, if any, between (a) a count of a sample of the votes cast on paper optical scan ballots, and (b) the tally of those votes from the optical scan machine that counted the ballots in the selected precincts on election day; and

2. To collect information about the pilot experience that facilitates understanding the implementation factors, including time, cost, and the statistical considerations associated with various post-election audit methods.

PILOT POST-ELECTION AUDIT METHODOLOGY AND PLANNING

JLARC staff worked with SBE staff, the Virginia Electoral Board Association, and the Voter Registrars' Association of Virginia to ask localities to participate in the pilot. Four localities that use optical scan machines volunteered: the City of Charlottesville, and Chesterfield, Fairfax, and Page counties. Once general agreement was reached with these localities on participation, JLARC staff began developing a proposed audit approach. This approach was shared with these localities, SBE, the Democratic and Republican Parties of Virginia, as well as Virginia Verified Voting. Feedback from these groups was incorporated as appropriate, culminating in an audit guidebook, instructions, and forms to be used in each locality. These materials were developed using two primary sources: (1) existing SBE policy for recounts in Virginia and (2) other states' approaches to post-election audits.

After the November 2009 election results were available, JLARC staff analyzed the results of each election on the ballot in each pre-

cinct in the four participating localities. Races and precincts were selected based on statutory requirements, essentially intended to audit races with substantial margins of victory and precincts with other elections on the ballot also with substantial margins of victory. More information about this race and precinct selection process can be found in Appendix B.

JLARC staff then notified each candidate on each ballot in each precinct selected for the audit. The state and local Democratic and Republican parties were also notified. On January 15, 2010, SBE approved the general approach for the pilot audit project, as well as the required notification to the clerk of the circuit court in each of the four localities that would allow access to the ballots in each precinct.

PAGE COUNTY PILOT AUDIT

The Page County pilot audit occurred on February 3, 2010 at the Page County courthouse. The Page County Registrar served as the audit coordinator, while two JLARC staff served as audit officials. The Page County Electoral Board as well as a representative from the Page County Democratic Committee also observed the audit. The Attorney General race from the November 2009 election was the race selected for audit. The Republican Party candidate was Ken T. Cuccinelli II and the Democratic Party candidate was Stephen C. Shannon. Two precincts were selected for audit and voters in both precincts used the Optech IIIPE optical scan machine manufactured by Sequoia Voting Systems. The audit in Page County was conducted using a hand-to-eye count method, sorting ballots by vote into groups of five ballots (Figure C-1).

Figure C-1: Audit Officials Used the Hand-to-Eye Count Method During the Page County Pilot Audit

Optical Scan Ballots

Ballots Sorted and Stacked

Source: Page County pilot post-election audit, Page County Electoral Board, 2010.

Audit of Precinct 501- Shenandoah

At 9:12, audit officials opened the box obtained from the clerk of the circuit court containing the ballots cast in precinct 501. At 9:15, audit officials began counting to compare the total number of ballots with what the Statement of Results (SOR) indicated was the total number of ballots read by the optical scan machine on election day. Audit officials ended this initial count at 10:00, concluding that there were 1,051 total ballots. After this conclusion was reached, the audit coordinator informed the audit officials that the SOR indicated there were 1,054 ballots read by the machine on election day.

Audit officials then reexamined their stacks to ensure that each stack of 100 ballots included 20 groups of five ballots, which they did. Audit officials then reexamined each group of five ballots to ensure that each included exactly five. During this process, one audit official found three groups of five ballots that actually included six ballots. These three additional ballots were then added to the initial count of 1,051, resulting in 1,054 total ballots which matched the total on the SOR.

The two audit officials then began grouping the ballots by candidate at 10:35. Audit officials looked at each ballot, then placed it in one of the following piles: clear vote for Cuccinelli; clear vote for Shannon; a "questionable" vote for Cuccinelli or Shannon that may or may not have been read by the optical scan machine, but could easily be identified by the audit official that the voter intended to vote for Cuccinelli or Shannon; write-in vote for Attorney General; or no vote for Attorney General. Once any of these piles reached five ballots, the group of five ballots was placed into a larger pile of similarly cast ballots.

The audit officials ended this count by candidate at 12:05, concluding that Cuccinelli received 683 votes, Shannon had received 311 votes, and there were 60 blank ballots or write-ins. After this conclusion was reached, the audit coordinator informed the audit officials that the SOR indicated Cuccinelli received 679 votes, Shannon received 309 votes, and there were 66 write-ins or no votes for Attorney General.

Audit officials then reexamined their pile of questionable ballots. There were 16 such ballots for Cuccinelli and 12 such ballots for Shannon. In the Cuccinelli pile there was a ballot marked with an "X" next to Cuccinelli's name but well outside the area where the machine was programmed to look for a mark. In the Shannon pile there was a ballot that was torn across the mark for Shannon. Audit officials were confident that the machine likely did not read either of these ballots. However, without running the ballots back

through an optical scan machine, audit officials could not identify any other ballots that could be definitively identified as not being read by the machine.

The audit of precinct 501 concluded at 12:25, with the audit officials and audit coordinator concurring that the difference of 4 ballots for Cuccinelli and 2 ballots for Shannon was most likely due to the optical scan machine not reading these ballots. Each of these ballots were likely in the pile of questionable ballots, though other than the ballot with the "X" next to Cuccinelli's name and the ballot that was torn across the mark for Shannon, it was inconclusive which of the other ballots in the questionable pile were the ones not read by the machine. The time and results of the audit of precinct 501 are summarized in Table C-1.

Table C-1: Page County Precinct 501 Audit Findings

Ballots and Time		Results			
			Statement of Results	*Audit*	*Difference (SOR – Audit)*
Ballots audited	1,054	Cuccinelli	679	683	-4[a]
Total audit time (minutes)	193	Shannon	309	311	-2[a]
Ballots audited / minute	5.5	Write-ins/ under-votes/ over-votes	66	60	6[a]
Ballots audited/ person / minute	2.7	**Totals**	*1,054*	*1,054*	*0*

[a]Audit officials concluded these ballots were not read by the optical scan machine, but were ballots that could be identified by the audit official as being cast by the voter for one candidate or the other.

Source: JLARC staff analysis of pilot audit of Page County precinct 501.

Audit of Precinct 401 – Newport

Due to the length of time required to conduct the audit of precinct 501 earlier in the morning, audit officials and the audit coordinator agreed to streamline the audit approach for precinct 401. Rather than counting the ballots once to determine a total, then recount all of them to determine totals by candidate, this step would be consolidated so that each ballot would be handled by each audit official fewer times.

At 12:50, audit officials opened the box containing the ballots cast in precinct 401. At 12:55, audit officials began grouping the ballots by candidate, using the same piles as in precinct 501. The audit officials took a lunch break from 1:20 to 1:45. Then, at 2:30, the audit officials concluded that there were 905 total ballots. After this conclusion was reached, the audit coordinator informed the audit officials that the SOR indicated there were also 905 ballots read by the machine on election day.

Because of the consolidated approach used during this audit, audit officials were then ready to conclude that Cuccinelli received 624 votes, Shannon received 224 votes, and there were 57 write-ins or no votes for Attorney General. After this conclusion was reached, the audit coordinator informed the audit officials that the SOR indicated Cuccinelli received 622 votes, Shannon received 226 votes, and there were 57 write-ins or no votes.

Audit officials then reexamined their stacks to ensure that each stack of 100 ballots included 20 groups of five ballots, which they did. Audit officials then decided to examine all ballots in the pile for Cuccinelli to see if there were ballots cast for Shannon that an audit official mistakenly placed in the Cuccinelli pile. During this process, one audit official found two ballots clearly marked for Shannon that were in the Cuccinelli pile. These two ballots were removed from the Cuccinelli total and added to the Shannon total, resulting in 622 votes for Cuccinelli and 226 votes for Shannon—matching the SOR totals.

The audit of precinct 401 concluded at 3:07, with the audit officials and audit coordinator concurring that the audit results matched the election day results. The time and results of the audit of precinct 401 are summarized in Table C-2.

Table C-2: Page County Precinct 401 Audit Findings

Ballots and Time		Results			
			Statement of Results	*Audit*	*Difference (SOR – Audit)*
Ballots audited	905	Cuccinelli	622	622	0
Total audit time (minutes)	112	Shannon	226	226	0
Ballots audited / minute	8.0	Write-ins/ under-votes/ over-votes	57	57	0
Ballots audited / person / minute	4.0	**Totals**	*905*	*905*	*0*

Source: JLARC staff analysis of pilot audit of Page County precinct 401.

CITY OF CHARLOTTESVILLE PILOT AUDIT

The City of Charlottesville pilot audit occurred on February 18, 2010 at the City's General Registrar's office in the City Hall Annex. The Charlottesville registrar served as the audit coordinator, while two JLARC staff served as audit officials. Two Charlottesville registrar staff, one SBE staff, and one interested citizen observed the audit. The race for the Democratic nominee for Governor from the June 2009 Democratic primary was the race selected for the audit. The three candidates were R. Creigh Deeds, Brian J. Moran, and Terry R. McAuliffe. Only absentee ballots mailed in-

to the Registrar's office used an optical scan machine for this election. These ballots were read using an eScan optical scan machine manufactured by Hart InterCivic. The audit in Charlottesville was conducted first using a machine-assisted method and then a hand-to-eye count method, with one audit official calling the vote while the other audit official tallied the vote.

Machine-Assisted Audit

At 9:30, audit officials opened the envelope containing the absentee ballots cast on optical scan ballots. Then the audit coordinator turned on the eScan optical scan machine and inserted a Mobile Ballot Box. The Mobile Ballot Box was programmed to read the ballots and save the results. An audit official entered the polling place identification number and password into the machine. Then the machine printed a zero tape showing that zero votes were cast on the machine. Next, an audit official entered the password again to open the polls. An audit official fed all the ballots into the machine. When all the optical scan ballots had been inserted into the optical scanner, the audit official entered the password to close the poll. Then the audit coordinator removed the Mobile Ballot Box and inserted it into a reader connected to a computer. The audit coordinator used a program to read and tabulate the votes captured on the Mobile Ballot Box. This tabulation matched the Statement of Results from Election Day. This audit concluded at 9:58 a.m. The time and results of the audit are summarized in Table C-3.

Table C-3: City of Charlottesville Central Absentee Precinct Machine-Assisted Audit Findings

Ballots and Time		Results			
			Statement of Results	*Audit*	*Difference (SOR-Audit)*
Ballots audited	41	Deeds	26	26	0
Total audit time (minutes)	28	McAuliffe	10	10	0
Ballots audited / minute	1.5	Moran	5	5	0
		Totals[a]	*41*	*41*	*0*

[a]Total includes an absentee ballot sent by overseas military personnel that was in PDF form. This ballot was not included in the machine tally from election day.

Source: JLARC staff analysis of pilot audit of City of Charlottesville of the Central Absentee Precinct.

Hand-to-Eye Count Audit

At 10:07 a.m., audit officials began hand-counting the ballots. The audit officials used a tallying method to conduct the hand-count, where one audit official (the caller) said the name of the candidate voted on each ballot, and the other audit official (the tallier)

marked a tally sheet for each vote. The audit officials concluded the hand count at 10:10 a.m. They concluded that 41 ballots were cast, 26 for Deeds, 10 for McAuliffe, and 5 for Moran. These results matched the Statement of Results, and the audit was completed. The time and results of the audit are summarized in Table C-4.

Table C-4: City of Charlottesville Central Absentee Precinct Hand-to-Eye Count Audit Findings

Ballots and Time		Results			
			Statement of Results	*Audit*	*Difference (SOR-Audit)*
Ballots audited	41	Deeds	26	26	0
Total audit time (minutes)	3	McAuliffe	10	10	0
Ballots audited / minute	13.7	Moran	5	5	0
		Totals[a]	*41*	*41*	*0*

[a]Total includes an absentee ballot sent by overseas military personnel that was in PDF form. This ballot was not included in the machine tally from election day.

Source: JLARC staff analysis of pilot audit of City of Charlottesville of the Central Absentee Precinct.

CHESTERFIELD COUNTY PILOT AUDIT

The Chesterfield County audit took place on March 10, 2010 at the Chesterfield County circuit court clerk's office in the Chesterfield County courthouse. The Chesterfield County general registrar served as the audit coordinator, while three JLARC staff served as audit officials. Two members of the Chesterfield County Electoral Board observed the first half of the audit, and two interested citizens observed the entire audit. The Attorney General race from the November 2009 election was the race selected for the audit. The Republican Party candidate was Ken T. Cuccinelli, II, and the Democratic Party candidate was Stephen C. Shannon. Two precincts were selected for the audit and voters in both precincts used the M-100 optical scan machine manufactured by Election Systems and Software (ES&S). The audit in Chesterfield County was conducted using a hand-to-eye count method, sorting ballots by vote into groups of five ballots.

Audit of Precinct 511 – Black Heath

At 9:00, audit officials opened the envelope obtained from the clerk of the circuit court containing the ballots cast in precinct 511. At 9:04, audit officials began grouping the ballots by candidate. Audit officials placed ballots in one of the following piles: clear vote for Cuccinelli; clear vote for Shannon, a "questionable" vote for Cuccinelli or Shannon that may or may not have been read by the optical scan machine, but could easily be identified by the audit official that the voter intended to vote for Cuccinelli or Shannon; or no

vote for Attorney General. Once any of these piles reached five ballots the group of five ballots was placed in a larger stack of similarly cast ballots. Each larger stack was to include 20 stacks of 5 ballots, for a stack of 100 ballots.

Once all the ballots were sorted and stacked, the audit coordinator gave one of the audit officials a separate envelope containing the write-in votes for the precinct. This envelope contained ballots on which a voter wrote-in a candidate for any office. Most of the ballots in this envelope contained a write-in vote for some office other than Attorney General. The audit officials sorted these votes into the same categories as used for other ballots, plus they added a stack for write-in votes. The audit officials kept these ballots segregated from the other ballots to ensure that they were returned to the separate write-in envelope at the end of the audit.

The audit officials concluded their sorting at 9:50 and began compiling a total. At 10:10, the audit officials concluded that there were a total of 1,227 ballots. After this conclusion was reached, the audit coordinator informed the audit officials that the Statement of Results (SOR) indicated there were 1,230 ballots read by the machine on election day. Audit officials then reexamined their stacks to ensure that each stack of 100 ballots included 20 groups of five ballots, which they did. Audit officials then reexamined each group of five ballots to ensure that each included exactly five. During this process, the audit officials found three groups of five ballots that actually included six ballots. These three additional ballots were then added to the initial count of 1,227, resulting in 1,230 total ballots which matched the total on the SOR. This process lasted until 10:27.

Then the audit officials began totaling votes for each candidate concluding at 10:33. The audit officials concluded that Cuccinelli received 907 votes, Shannon received 316 votes, and there were 7 write-ins or no votes for Attorney General. After this conclusion was reached, the audit coordinator informed the audit officials that the SOR indicated that Cuccinelli receive 905 votes, Shannon received 318 votes, and there were 7 write-ins or no votes.

At 10:36, the audit officials began reexamining all ballots in the Cuccinelli piles to see if there were any ballots cast for Shannon that an audit official mistakenly placed in a Cuccinelli pile. During this process, the audit officials found two ballots clearly marked for Shannon that were in the Cuccinelli pile. These two ballots were removed from the Cuccinelli total and added to the Shannon total, resulting in 905 votes for Cuccinelli and 318 votes for Shannon—matching the SOR totals. The process concluded at 10:51.

The audit of precinct 511 concluded at 10:51, with the audit officials and audit coordinator concurring that the audit results matched the election day results. The time and results of the audit of precinct 511 are summarized in Table C-5.

Table C-5: Chesterfield County Precinct 511 Audit Findings

Ballots and Time		Results			
			Statement of Results	*Audit*	*Difference (SOR – Audit)*
Ballots audited	1,230	Cuccinelli	905	905	0
Total audit time (minutes)	111	Shannon	318	318	0
Ballots audited / minute	11.1	Write-ins / under-votes / over-votes	7	7	0
Ballots audited / person / minute	3.7	**Totals**	*1,230*	*1,230*	*0*

Source: JLARC staff analysis of pilot audit of Chesterfield County precinct 511.

Audit of Precinct 307 – Cosby

At 12:35, the audit officials opened the envelopes containing the ballots for precinct 307, and they began sorting and stacking the ballots. Audit officials used the same sorting method they had used earlier in the day for precinct 511 for precinct 307. Audit officials looked at each ballot, and placed ballots in one of five piles. Once any of these piles reached five ballots, the group of five ballots was placed in a larger stack of similarly cast ballots. Each larger stack was to include 20 stacks of 5 ballots, for a stack of 100 ballots. Again, when all the ballots had been sorted and stacked, the audit coordinator gave an audit official the envelope for write-in ballots. The audit officials added these ballots into the totals as appropriate. At 1:18, all ballots had been sorted and stacked, and the audit officials began totaling the ballots. At 1:25, the audit officials concluded there were 1,212 ballots. The audit coordinator informed the audit officials that this total matched the total on the SOR.

Then the audit officials began totaling votes for each candidate at 1:30, and they concluded at 1:32. The audit officials concluded that Cuccinelli received 898 votes, Shannon received 310 votes, and there were 4 write-ins or no votes for Attorney General. After this conclusion was reached, the audit coordinator informed the audit officials that the SOR indicated that Cuccinelli received 897 votes, Shannon received 311 votes, and there were 4 write-ins or no votes.

At 1:32, the audit officials began reexamining all ballots in the Cuccinelli piles to see if there were any ballots cast for Shannon that an audit official mistakenly placed in a Cuccinelli pile. During

this process, the audit officials found one ballot clearly marked for Shannon that was in the Cuccinelli pile. This ballot was removed from the Cuccinelli total and added to the Shannon total, resulting in 897 votes for Cuccinelli and 311 votes for Shannon—matching the SOR totals. The process concluded at 1:44.

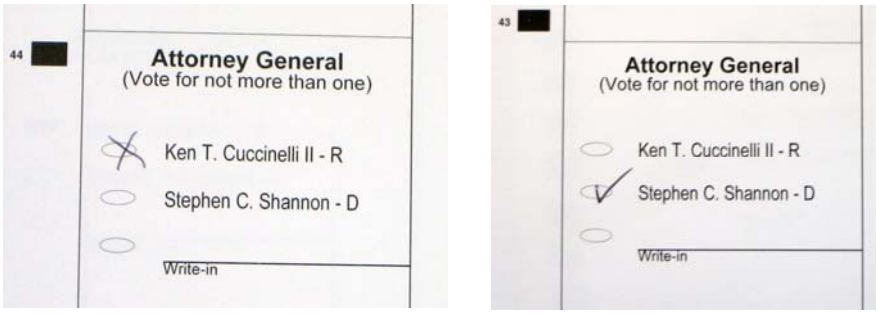
The audit of precinct 307 concluded at 1:44, with the audit officials and audit coordinator concurring that the audit results matched the election day results. The time and results of the audit of precinct 307 are summarized in Table C-6. Audit officials noted that the machines were quite adept at tabulating ballots that were not filled-out according to the instructions given. The ballots shown in Figure C-2 are two examples of several that were correctly tabulated on election day, despite the fact that the instructions were to fill-in the oval.

Table C-6: Chesterfield County Precinct 307 Audit Findings

Ballots and Time		Results			
			Statement of Results	*Audit*	*Difference (SOR – Audit)*
Ballots audited	1,212	Cuccinelli	897	897	0
Total audit time (minutes)	69	Shannon	311	311	0
Ballots audited / minute	17.6	Write-ins / under-votes / over-votes	4	4	0
Ballots audited / person / minute	5.9	**Totals**	*1,212*	*1,212*	*0*

Source: JLARC staff analysis of pilot audit of Chesterfield County precinct 307.

Figure C-2: Examples of Incorrectly Completed Ballots Still Tabulated Correctly By M-100 Optical Scan Machine (Ovals Were To Be Filled In)

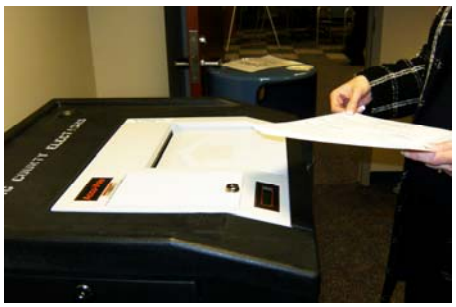


Source: JLARC staff photos.

FAIRFAX COUNTY PILOT AUDIT

The Fairfax County audit took place on March 15, 2010 at the Fairfax County courthouse. The Fairfax County general registrar served as the audit coordinator, while six Fairfax County general registrar staff served as audit officials. Two JLARC staff observed the audits, provided general guidance upon request, and took notes on the procedures used and time. Two members of the Fairfax County Electoral Board observed part of the audit, and one interested citizen observed the entire audit. The House of Delegates District 45 race from the November 2009 election was the race selected for the audit. The Republican Party candidate was Vicki L. Vasques and the Democratic Party candidate was David L. Englin. Three precincts were selected for the audit and voters in all three precincts could choose to vote on a WinVote DRE or on an optical scan ballot fed through an AccuVote optical scanner manufactured by Premier Election Solutions. These three audits only audited those ballots cast on the optical scanners. The audit in Fairfax County was first conducted using a machine-assisted method, and then conducted using a hand-to-eye count method (Figure C-3).

Figure C-3: Machine-Assisted and Hand-to-eye Count Audit in Fairfax County



Machine-assisted Count

Hand-to-eye Count

Source: JLARC staff photos taken at Fairfax County post-election audit pilot, March 15, 2010.

Machine-Assisted Audit

When JLARC staff arrived at the audit location, the ballots and optical scanners were locked in a secure storage area in the courthouse. The chief deputy clerk of the Fairfax County circuit court led the audit coordinator, two audit officials and the two JLARC staff to this area to retrieve the optical scanners and ballots. Upon their return to the conference room hosting the audit at 8:53, the audit officials began to set the optical scanners up for use. Each optical scanner required approximately five minutes of set-up time.

Next, the audit officials conducted a logic and accuracy (L&A) test on each of the three optical scanners to be used. An audit official inserted a memory card into the optical scanner and then turned the machine on. Then four test ballots that the audit officials had previously filled in by hand were fed through the machines in different orientations. The optical scanners then printed a tape showing the results of the L&A test. Each of the three machines passed the L&A test. Then the audit officials printed a zero tape on each of the machines to show that no ballots had been yet cast on the machine. The L&A test took approximately eight minutes per machine, and was completed on all machines at 9:25.

Audit of Precinct 408 – Mount Eagle. At 9:27, audit officials opened the boxes containing the optical scan ballots from precinct 408. One audit official fed the ballots through the machine while the other monitored the machine to see if each ballot was being accepted and tallied. All the ballots had been fed through the scanner by 9:55. The audit officials completed printing the results tape at 10:02, then shut down the machine. By, 10:10, the audit officials had removed the ballots from the locked ballot box under the optical scan machine. As shown in Table C-7, the machine-assisted audit results matched the election day results.

Audit of Precinct 608 – Kirkside. At 9:28, audit officials opened the boxes containing the optical scan ballots from precinct 608. The two audit official alternated feeding all the ballots into the machine. All the optical scan ballots had been inserted into the optical scanner at 10:20. The audit officials completed printing the results tape at 10:26, and then shut down the machine. At 10:32, the audit officials completed unloading the ballots from the locked ballot box under the optical scanner.

As shown in Table C-7, the results the optical scanner produced during the machine-assisted audit for Precinct 608 differed from the results produced on election day. The optical scanner counted one more ballot than what was counted on election day, it attributed one more vote to Vasques and two more votes to Englin, and it found two fewer under-votes. Two of the votes attributed to candidates were likely votes that the machine was unable to read on election day and counted as under-votes, while the third additional vote attributed to one of the candidates was likely the additional ballot not counted on election night. However, the fact that the audit yielded one more ballot than the election night total is unexplainable.

Audit of Precinct 621 – Grosvenor. At 9:27, audit officials opened the boxes containing the optical scan ballots from precinct 621. One audit official fed the ballots through the machine while the other monitored the machine to see if each ballot was being ac-

cepted and tallied. All the ballots had been fed through the scanner by 9:51. The audit officials completed printing the results tape at 9:54, then shut down the machine. By, 10:01, the audit officials had removed the ballots from the locked ballot box under the optical scan machine. As shown in Table C-7, the machine-assisted audit results matched the election day results.

Table C-7: Fairfax County Machine-Assisted Audit Findings

Precinct 408 – Mount Eagle Machine-Assisted Audit Findings					
Ballots and Time		**Results**			
			Statement of Results	*Audit*	*Difference (SOR – Audit)*
Ballots audited	519	Vasques	150	150	0
Total audit time (minutes)	50	Englin	360	360	0
Ballots audited / minute	10.4	Write-ins / under-votes / over-votes	9	9	0
Ballots audited / person / minute	5.2	**Totals**	*519*	*519*	*0*
Precinct 608 – Kirkside Machine-Assisted Audit Findings					
Ballots and Time		**Results**			
			Statement of Results	*Audit*	*Difference (SOR – Audit)*
Ballots audited	902	Vasques	299	300	-1[a]
Total audit time (minutes)	72	Englin	591	593	-2[a]
Ballots audited / minute	12.5	Write-ins / under-votes / over-votes	11	9	2[a]
Ballots audited / person / minute	6.3	**Totals**	901	902	-1[b]
Precinct 621 – Grosvenor Machine-Assisted Audit Findings					
Ballots and Time		**Results**			
			Statement of Results	*Audit*	*Difference (SOR – Audit)*
Ballots audited	439	Vasques	163	163	0
Total audit time (minutes)	42	Englin	271	271	0
Ballots audited / minute	10.5	Write-ins / under-votes / over-votes	5	5	0
Ballots audited / person / minute	5.2	**Totals**	*439*	*439*	*0*

[a]Audit officials concluded these ballots were not read by the optical scan machine and were counted as under-votes on election day, but these ballots could be identified by the audit official as being cast by the voter for one candidate or the other.

[b]The Statement of Results for election day reported a total of 901 optical scan votes; however, both the machine-assisted and hand count audits had totals of 902 optical scan votes. This difference is unexplainable.

Source: JLARC staff analysis of pilot audit of Fairfax County machine-assisted audit.

Hand-to-Eye Count Audit

Following a brief break, the audit coordinator assigned each team of audit officials to the same precinct they counted in the machine-

assisted audit. As with the machine-assisted audit, two audit officials were assigned to each precinct. Each team sorted the ballots into large piles: ballots clearly marked for Englin; ballots clearly marked for Vasques; ballots with no vote for the office; ballots with a write-in votes; and ballots with a "questionable" vote for Englin or Vasques that may or may not have been read by the optical scan machine, but could easily be identified by the audit official that the voter intended to vote for Englin or Vasques. The audit officials then counted the number of ballots in each pile to arrive at a total. The three audits discussed below were performed concurrently.

Audit of Precinct 408 – Mount Eagle. At 10:51, the audit officials began the hand-to-eye count of ballots for precinct 408. The audit officials each took a pile of ballots and then began sorting them by candidate. Both audit officials put ballots into shared piles. At 11:12, the audit officials completed counting and stacking the ballots, and began totaling. The audit officials concluded that 518 ballots had been cast, with 361 ballots for Englin, 149 ballots for Vasques, six write-in votes, and two under-votes. At 11:24, audit officials checked with the audit coordinator to obtain the election day results. The total number of ballots on election day was 519, with 360 for Englin, 150 for Vasques, six write-in votes, and three under-votes.

At 11:26, the audit coordinator asked two other audit officials to conduct the hand-to-eye count again. This second audit team finished totaling the ballots at 11:44, getting the same totals as the first audit team. Audit officials then began looking in the optical scan machine ballot box used for the machine-assisted audit to see if a ballot had not been removed from the earlier session. Audit officials continued to look, then found a ballot cast in precinct 408 that was mistakenly placed in the test deck of ballots used to conduct the L&A test at the beginning of the day. This ballot was a vote for Englin, which brought his total to 362 and brought the total number of ballots to 519. These totals and the election day totals are shown in Table C-8.

At 11:53, the audit coordinator and audit officials then decided to run the questionable ballots for each candidate through the optical scan machine again. The machine properly tabulated all the questionable ballots. By 12:02, audit officials determined the hand-to-eye count had concluded and that the hand-to-eye count was able to tabulate an under-vote that the machines could not. The differences in candidate vote totals between the hand-to-eye count and machine-assisted and election day totals, however, could not be explained.

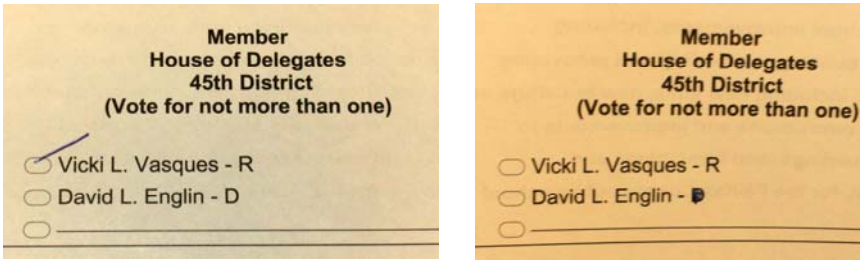
Audit of Precinct 608 – Kirkside. At 10:51, the audit officials began the hand-to-eye count of ballots for precinct 608. The audit officials

divided the pile in half and began by sorting ballots by candidate. Each audit official had their own piles of ballots, organized as discussed above. At 11:13, the audit officials completed sorting the ballots by candidate and started counting the ballots by ten making stacks of 100 ballots.

The audit officials completed counting and stacking the ballots at 11:30 and they began totaling the ballots. The audit officials concluded that 902 ballots had been cast in the election with 596 votes cast for Englin, 301 votes cast for Vasques, one write-in votes, and four under-votes. The audit coordinator informed the audit officials that the election day tally had counted 901 ballots with 591 votes for Englin, 299 votes for Vasques, one write-in vote, and ten under-votes. These totals are shown in Table C-8.

At 11:55, the audit coordinator and audit officials decided to run the questionable ballots for each candidate through the optical scan machine again. The audit officials fed five ballots through the machine, which they had previously segregated as ballots with a "questionable" vote for Englin or Vasques that may or may not have been read by the optical scan machine, but could easily be identified by the audit official that the voter intended to vote for Englin or Vasques. The machine properly tabulated three of these questionable ballots. One vote that was not tabulated by the machine had only a very thinly marked check in the target area for Vasques, as shown in Figure C-3. The other vote that was not tabulated did not have any mark in the target areas for either candidate, but the "D" next to Englin's name was colored in, as shown in Figure C-4. Since the machine did not read these ballots, they are not included in the totals for the candidates.

Figure C-4: "Questionable" Votes in Precinct 608



Source: Hand-to-Eye Count Pilot Post-election Audit, Fairfax County, March 15, 2010.

The audit officials concluded that four of the additional votes they had attributed to candidates were likely counted as under-votes by the optical scanner on election day because they contained non-standard marks. They also concluded that a fifth additional vote

they had attributed to a candidate was likely the extra ballot that had not been counted on election day. However, it was unclear why one more ballot was counted during the audit than on election day. The audit concluded at 12:22.

Audit of Precinct 621 – Grosvenor. At 10:51, the audit officials began the hand-to-eye count of ballots for precinct 621. The audit officials each took a pile of ballots and then began sorting them by candidate. Both audit officials put ballots into shared piles. At 11:10, the audit officials completed counting and stacking the ballots and began getting a total. The audit officials concluded that 439 ballots had been cast, with 271 ballots for Englin, 163 for Vasques, zero write-in votes, and five under-votes. At 11:19, audit officials checked with the audit coordinator to obtain the election day results. As shown in Table C-8, the hand-to-eye count totals matched the election day totals.

Table C-8: Fairfax County Hand-to-Eye Count Audit Findings

Precinct 408 – Mount Eagle Hand-to-Eye Count Audit Findings					
Ballots and Time		**Results**			
			Statement of Results	*Audit*	*Difference (SOR – Audit)*
Ballots audited	519	Vasques	150	149	1
Total audit time (minutes)	71	Englin	360	362	-2
Ballots audited / minute	7.3	Write-ins / under-votes / over-votes	9	8	1
Ballots audited / person / minute	3.6	**Totals**	*519*	*519*	*0*
Precinct 608 – Kirkside Hand-to-Eye Count Audit Findings					
Ballots and Time		**Results**			
			Statement of Results	*Audit*	*Difference (SOR – Audit)*
Ballots audited	902	Vasques	299	300 [b]	-1 [a, b]
Total audit time (minutes)	91	Englin	591	595 [b]	-4 [a, b]
Ballots audited / minute	9.9	Write-ins / under-votes / over-votes	11	7 [b]	4 [b]
Ballots audited / person / minute	5.0	**Totals**	901	902	-1 [c]
Precinct 621 – Grosvenor Hand-to-Eye Count Audit Findings					
Ballots and Time		**Results**			
			Statement of Results	*Audit*	*Difference (SOR – Audit)*
Ballots audited	439	Vasques	163	163	0
Total audit time (minutes)	28	Englin	271	271	0
Ballots audited / minute	15.7	Write-ins / under-votes / over-votes	5	5	0
Ballots audited / person / minute	7.8	**Totals**	*439*	*439*	*0*

[a] Audit officials concluded that four of these five additional votes attributed to candidates in the hand count audit were ballots that were not read by the optical scan machine and were counted as under-votes on election day, but these ballots could be identified by the audit official as being cast by the voter for one candidate or the other. One of these additional ballots was the additional ballot that was not included in the election day total.

[b] Although the audit officials counted attributed two ballots to candidates, one to Vasques and one to Englin, that they were able to interpret but the optical scanner could not read (these votes are pictured in Figure C-4), these votes are not attributed to the candidates in these totals, and rather are counted in this table as under-votes.

[c] The statement of results for election day reported a total of 901 optical scan votes; however, both the machine-assisted and hand count audits had totals of 902 optical scan votes. This difference is unexplainable.

Source: JLARC staff analysis of pilot audit of Fairfax County hand-to-eye count audit.

Appendix D

Post-election Audits in Other States

To collect current and accurate information regarding other states' post-election audit programs, JLARC staff administered a survey to state-level election staff in other states. The National Association of State Election Directors (NASED) distributed the survey to their members, and staff in 25 states responded, including the District of Columbia. Of those who responded to the survey, 13 states plus the District of Columbia indicated that they had a post-election audit program in place. These states' responses to a selection of the survey questions regarding their post-election audit program are shown in the table.

Table D-1: Audit Design and Implementation

State	Year of most recent revision to audit law	Method to conduct audits	When are audits conducted?	Sample size selection strategy	Who conducts audits?	Who funds audits?
AZ	2009	HTEC	After certification, before recount deadline	FP	Party appointees	Local
AR	2009	Combo	Before certification	FP	Local election staff; State employees; Poll workers; Volunteers	--
CO	2009	Combo	Before certification	AP	Poll workers	Local
CT	2007	HTEC	Before certification	FP	Local election staff; Poll workers	Local
DC	2009	Combo	After certification, before recount deadline	AP	Local election staff; Poll workers; Volunteers	N/A
FL	N/A	HTEC	After certification, before recount deadline	FP	Poll workers; Volunteers	Local
IL	2007	MA	Before certification	FP	Local election staff	Local
MT	2009	HTEC	Before certification	FP	Local election staff; State employees; Volunteers	State
NV	2007	Combo	Before certification	FP	Local election staff	Local
NC	2005	HTEC	Before certification	AP	Local election staff	Local
PA	Prior to 1990	Combo	Before certification	AP	Local election staff	Local
WA	2005	HTEC	Before certification	FP	Local election staff	Shared
WV	2008	HTEC	Before certification	FP	Local election staff	Local
WI	2006	HTEC	After recount deadline	FP	Local election staff; State election staff	State

Note: HTEC - Hand-to-Eye Count; MA - Machine-Assisted; FP - Fixed-percentage; AP - Adjustable-percentage.

Source: JLARC staff survey of other states, January and February 2010.

Table D-2: Audit Results

State	Usefulness of audits for the following purposes: *Verifying election results?*	*Checking accuracy of voting equipment?*	*Enhancing election transparency?*	*Increasing voter confidence?*	Extent to which audits find the following discrepancies between election day results and audit results: *Less than 1%?*	*1% or greater?*	*3% or greater?*	*5% or greater?*	*Large enough to change election results?*	Are audits an effective use of resources?
AZ	Very useful				Rarely	Never	Never	Never	Never	--
AR	Very useful	Very useful	Somewhat useful	Very useful			Rarely			--
CO	Very useful						Never			Effective
CT	Not useful	Somewhat useful	Very useful	Very useful	Rarely	Rarely	Never	Never	Never	Effective
DC	Very useful				Sometimes	Never	Never	Never	Never	Highly effective
FL	Somewhat useful	Somewhat useful	Very useful	Very useful	Sometimes	Rarely	Never	Never	Never	Somewhat effective
IL	Very useful				Sometimes	Never	Never	Never	Never	Effective
MT	Not useful	Very useful	Very useful	Very useful			Rarely			Somewhat effective
NV	Very useful						Never			Highly effective
NC	Very useful				Often	Rarely	Never	Never	Never	Highly effective
PA	Very useful						Never			Effective
WA	Very useful				Sometimes	Never	Never	Never	Never	Highly effective
WV	Somewhat useful				Rarely	Never	Never	Never	Never	Somewhat effective
WI	Somewhat useful	Very useful	Very useful	Very useful			Never			Effective

Source: JLARC staff survey of other states, January and February 2010.

Appendix E

Potential Changes to the *Code of Virginia* If Audits Are Required

Table E-1 identifies the sections of the *Code* and potential changes that would be necessary. Table E-2 identifies the existing procedures that would potentially be affected and the new procedures that would need to be created.

Table E-1: Potential Changes to the *Code of Virginia*

Code Section	Section Title	Potential Change If Audits Authorized
§24.2-103	Powers and duties in general	Designate responsibility among SBE and local electoral boards for setting post-election audit policies and procedures
§24.2-106	Appointment and terms; vacancies; chairman and secretary; certain prohibitions; training.	Designate responsibility for local electoral board for following post-election audit policies and procedures
§24.2-114	Duties and powers of general registrar	Designate responsibility to participate in and conduct post-election audits consistent with policies and procedures (may not be necessary because general registrar serves under direction of the local electoral board)
§24.2-116	Compensation of officers	Designate local electoral board with authority to determine rate of pay for participation in post-election audits
§24.2-600	Cost of elections	Determine responsibility among State and localities for cost of post-election audits
§24.2-659	Locking voting and counting devices after election and delivering keys to clerk; printed returns as evidence	Include procedures, if any, after polls close that would facilitate post-election audits being conducted, including storage of voting equipment, statements of results, and ballots
§24.2-668	Pollbooks, statements of results, and ballots to be sealed and delivered to clerk or general registrar	
§24.2-669	Clerk to keep ballots; inspection; destruction	
§24.2-671	Electoral board to meet and ascertain results; conclusiveness of results	Determine timing of post-election audits, and how conclusiveness of election results is delayed or affected by audit process and results (more likely needed if adjustable-strategy is used)
§24.2-671.1	Pilot programs for audits of optical scan tabulators	Remove section and replace with new, or amend to reflect new requirements for post-election audit program
§24.2-672	Electoral board to correct irregularities in returns of officers of election	Determine how timing and results of post-election audits affect local electoral board ability to correct irregularities in returns that are discovered during an audit
§24.2-673	Candidates having highest number of votes to receive certificate of election	Determine how timing and results of post-election audits affect award of certificates of election (more likely needed if adjustable-strategy is used)

Code Section	Section Title	Potential Change If Audits Authorized
§24.2-679	State Board to meet and make statement as to number of votes	Determine how timing and results of post-election audits would affect vote totals (more likely needed if adjustable-strategy is used)
§24.2-800	Recounts in all elections	Determine how post-election audit requirements would be consistent with recounts, in particular whether audit would still be carried-out if recount is requested and how timing would be affected (more likely needed if adjustable strategy is used)
§24.2-801	Petition for recount; recount court	
§24.2-808	Time of filing and service of complaint; enlargement or amendment of complaint	

Source: JLARC staff analysis of *Code of Virginia* and discussions with SBE staff and Virginia general registrars and electoral board members.

Table E-2: New Procedures and Potential Changes to Existing Procedures

Procedure	Potential Type of Change
SBE instructions and forms for post-election audits	Would need to create instructions and forms to be used by localities conducting post-election audits. Guidebook, instructions, and forms used for pilot could be used as starting point for further refinement.
Other SBE policy	"Standards for Recounts of Virginia Elections," including Attachment A would need to potentially be expanded / amended if hand-to-eye count method is chosen

Source: JLARC staff analysis of *Code of Virginia* and discussions with SBE staff and Virginia general registrars and electoral board members.

Appendix F

Agency Response

As a part of the extensive validation process, State agencies and other entities involved in a JLARC assessment are given the opportunity to comment on an exposure draft of the report. Appropriate technical corrections resulting from comments provided by these entities have been made in this version of the report. This appendix includes a written response from the State Board of Elections.

COMMONWEALTH of VIRGINIA
STATE BOARD OF ELECTIONS

June 3, 2010

Mr. Philip A. Leone, Director
Joint Legislative and Audit Review Commission
Suite 1100, General Assembly Building, Capitol Square
Richmond, VA 23219

Dear Mr. Leone:

I want to express appreciation for the opportunity to review and comment on the *Review of Post-election Audits of Voting Equipment.* The JLARC team, led by Justin Brown, worked closely with the State Board of Elections' staff and produced a well researched and organized study.

Your report validated our experience with the electoral system, including:

- Slight variations exist between hand counting and machine counting ballots but these variations are usually not enough to impact the outcome of an election;
- Postelection audits can benefit and strengthen the electoral system; and
- Postelection audits could require local resources which a number of general registrars oppose.

The accuracy of voting equipment is paramount to the proper administration of elections. Not only must voting equipment be accurate, but people must trust the accuracy of voting equipment. It is not enough that only election officials trust the electoral system; for democracy to flourish, the general public must also trust the system. For these reasons, the State Board of Elections supports efforts for greater transparency in election administration.

Postelection audits serve a critical role to close the loop on voting equipment security. Security requires detection mechanisms and oversight by trusted officials. Currently, voting equipment is tested before it is purchased (voting equipment certification), immediately after it is purchased (acceptance testing), and several days before an election (logic and accuracy testing). However, it is not tested after an election to ensure that the equipment operated properly. Postelection audits and investigations only occur when grossly erroneous results are reported such as happened in the March 9, 2009 special election in Fairfax County. While we maintain that physical security procedures make it incredibly difficult to tamper with voting equipment, the possibility of detecting, and thus deterring, such maliciousness can only be improved with postelection audits.

Washington Building – 1100 Bank Street - First Floor - Richmond 23219
Telephone 804-864-8901 - Toll-Free (800) 552-9745 – Fax 804-371-0194 – TTY 800-260-3466
http://www.sbe.virginia.gov

The report indicated a slight difference can exist between hand counted ballots and machine counted ballots. This mirrors the Florida 2000 Presidential Recount experience when election officials discovered that voters did not the complete either the optical scan or paper ballots according to the voting equipment instructions resulting in uncounted votes. These differences, while minute, are usually not the result of machine error or malicious behavior but rather voter error. We plan on working with the election community to better educate voters on how to correctly fill out the optical scan or paper ballots.

We recognize that some general registrars oppose any additional workload or drain on dwindling resources. Some believe that there are more efficient and/or effective ways to achieve voting equipment security. Your report accurately notes that local budgets will likely bear the cost of any postelection audits. For this reason, we appreciate that your report considered different types of postelection audits and their impact on local resources.

Some of the recommendations in your report can be implemented through administrative actions while others will require legislative approval. The State Board of Elections will work with all involved stakeholders to explore and implement any actions or alternatives that the General Assembly determines are appropriate responses to these recommendations. I look forward to attending the Commission's meeting and future collaboration with your office.

Sincerely,

Nancy Rodrigues
Secretary

JLARC Staff

Executive Staff

Philip A. Leone, Director
Glen S. Tittermary, Deputy Director

Division Chiefs

Robert B. Rotz, Senior Division Chief
Harold E. Greer III, Division Chief

Section Managers

Paula C. Lambert, Fiscal & Administrative Services
Gregory J. Rest, Research Methods
Walter L. Smiley, Fiscal Analysis

Project Leaders

Aris W. Bearse
Justin C. Brown
Ashley S. Colvin
Martha L. Erwin
Eric H. Messick
Nathalie Molliet-Ribet
Kimberly A. Sarte

Project Staff

Janice G. Baab
Jamie S. Bitz
Mark R. Gribbin
Bradley B. Marsh
Ellen J. Miller
Stefanie R. Papps
David A. Reynolds
Tracey R. Smith
Massey S. J. Whorley
Christine D. Wolfe

Administrative and Research Support Staff

Joan M. Irby
Betsy M. Jackson

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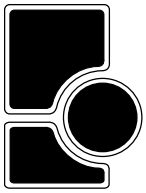

Joint Legislative Audit and Review Commission
Suite 1100
General Assembly Building
Capitol Square
Richmond, Virginia 23219
804-786-1258 Fax 804-371-0101
http://jlarc.virginia.gov