

# White Paper

## Consideration of Ohio Audits in 2008

Prepared by the Joint Audit Working Group<sup>1</sup>

February 19, 2008

### Executive Summary

- Properly conducted post–election audits can ensure that miscounts are corrected before certification.
- Fixed and Tiered audits tend to count too few votes in close races and too many votes on races that are not close.
- The recommended Statistical audit method provides a way to achieve a high level of confidence in the results at a minimum cost.
- A statewide post–election audit after the November 2004 election that followed the recommendations in this paper would have cost an estimated \$165,000.
- A statewide post–election audit after the November 2006 election (with its additional statewide races) that followed the recommendations in this paper would have cost an estimated \$260,000.
- Limiting the number of races to audit is recommended for the 2008 election and is estimated to cost less than \$100,000.

### Purpose of This White Paper

This White Paper was prepared to assist the Secretary of State, Ohio Election Officials, and Legislators as they consider legislative action in 2008 to institute post–election audit procedures. This paper provides background information and detailed recommendations on the different audit methods and how they might be used in Ohio.

This paper was written after a request from Secretary of State Brunner’s Voting Rights Institute (VRI) on January 15<sup>th</sup> for information on audits. The Joint Audit Working Group that wrote the paper includes members of the VRI’s Advisory Council with input from statisticians and election integrity experts. Opinions, findings, and conclusions or recommendations expressed in this paper are the responsibility solely of the authors and not a statement of the VRI or Secretary of State's office.

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<sup>1</sup> The Joint Audit Working Group includes members of the Secretary of State’s Voting Rights Institute’s Advisory Council, and an Advisory Panel experienced in election audits. See *Acknowledgements* at the end of this White Paper.

The purpose of post-election audits is to identify problems, to make it possible to correct them for the current election, and to make suggestions with the final audit report for future improvements. We all need to help educate the public and media that elections are complicated, some mistakes are inevitable, and an audit that finds and corrects problems should be regarded as a success.

The first few sections in the paper provide general background

- Background on Ohio
- Concern about Voting Systems
- What is a Post-election Audit?
- Interest in Post-election Audits
- Model Post-election Audit Provisions

The next sections present our recommendations for implementing audits

- Recommendations
- Cost Estimates
- Audits in 2008
- Further Study
- Conclusion
- Acknowledgments

## Background on Ohio

Ohio currently has no legislation requiring post-election audits, but does provide for recounts.

Ohio has 88 counties with various voting systems<sup>2</sup>

- 45 counties use Diebold AccuVote-TSX (DRE)
- 10 counties use ES&S iVotronic (DRE)
- 28 counties use ES&S Model 100 (OS) and ES&S AutoMark for ADA
- 2 counties use Hart eScan (OS) and Hart eSlate for ADA
- 1 county uses Diebold AccuVote-OS (OS) and Diebold AccuVote-TSX (DRE) ADA

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<sup>2</sup> <http://www.sos.state.oh.us/sos/info/EverestMAP.pdf> (as of 2/16/2008 this site was not updated to include changes for Cuyahoga and Van Wert counties) and <http://www.sos.state.oh.us/sos/yvc/main/map.htm>

- 2 counties use (OS) and central count M650 and Diebold AccuVote-TSX (DRE) ADA

The Secretary of State's December 2007 EVEREST report<sup>3</sup> found "Ohio's electronic voting systems have 'critical security failures' which could impact the integrity of elections."

## Concern about Voting Systems

After every election- and especially in what are sure to be a highly scrutinized Primary and General Presidential elections in 2008 - the public deserves to have a high level of confidence in the election results as they are announced by county and state officials.

Whether or not one believes our Optical Scan and DRE systems produce reliable election results when administered correctly, there clearly exists growing public concern that electronic tallies by themselves may not be reliable. While criticism of DRE's has made the most news, criticism of optical scan tallies is also suffering growing distrust due to reports of software and other security vulnerabilities. Meanwhile, no less than the National Institute of Standards and Technology and the EAC's Technical Guidelines Development Committee have pointed out that it is beyond the state of the art to produce error-free and completely secure software; and the draft version of the 2007 Voluntary Voting System Guidelines requires all voting systems to be software-independent, i.e. the election results should not depend on the particular software use.

It is in the interest of everyone to increase public confidence. We think we can avoid a nightmare of controversy, undue media scrutiny, endless review, public records requests, litigation, spiraling costs and distraction from subsequent elections. We want to work towards an election where the public is confident of the process and election officials can experience a more routine business of closing down election cycles, filing records to sit quietly in storage, and getting some rest.

The public deserves good elections. So do Ohio's election officials. Public confidence is the largest contributor to whether life will be businesslike or a nightmare for election officials.

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<sup>3</sup> <http://www.sos.state.oh.us/SOS/Info/everest.aspx>

Banks and Credit Card companies provide statements with transactions that allow their customers to check that their account balances are correct. Election “transactions” which are just as important to the majority, and produce results that have been shown for ages to be just as subject to human desire for unfair manipulations, are riskier than those of the bank. The majority does not have many known numbers with which to reconcile results. Thus, for the public’s trust, election officials cannot simply provide vote totals without any validation that the results are correct and that they have employed full and proper procedures such as secure chains of custody. Ohio law requires paper audit trails on DRE’s, but unless the audit trails are used, they provide no value. DRE vendors suggest and BOE’s use tamper-proof security seals, but the seal are also worthless unless they are checked. Election officials should be able to demonstrate that election results are accurate and a properly conducted and transparent post-election audit is a crucial part of doing that.

## **What is a Post-election audit?**

The term “audit,” as applied to elections, can mean many things and is often confusing. We prefer the term “post-election audit”<sup>4</sup> and define it generally as<sup>5</sup>:

The audit of election results, conducted after the polls have closed and before certification, by performing manual counts of paper ballots and voter-verifiable paper records in randomly selected units (e.g. precincts) and comparing them to the corresponding electronic or manual tallies, for the purpose of verifying the election result with a high level of confidence.

It is important to note that a post-election, pre-certification audit is one step among many to safeguard an election. An accurate count does not imply a fair election; it is but one essential step in safeguarding the vote for voters and election officials alike.

Some of the other important steps that need be done well include the following

- Accurately registering voters
- Developing, and verifying the use of, using security procedures

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<sup>4</sup> Also referred to as a pre-certification audit

<sup>5</sup> This definition comes from the 2007 Post-Election Audit Summit in Minnesota. <http://www.electionaudits.org/node/1>

- Developing, and verifying the use of, chain of custody procedures
- Directing voters to the correct precinct
- Reconciling signature books completely and investigating discrepancies
- Reviewing audits logs from tabulators and scanners

## Interest in Post–election Audits

- **An effective audit is an essential safeguard against problems identified in the EVEREST report.** Secretary Brunner’s EVEREST report includes numerous concerns about voting system problems and security risks. Replacing these systems before November 2008 in Ohio’s 88 counties does not appear to be practical. In this situation, an efficient and robust audit procedure is particularly important to find and correct mistakes and to discourage tampering.
- **Audits are not new, but awareness about the importance of audits is rapidly growing** and promises to continue to grow as the November 2008 election approaches. The reason is that the same people who raise concerns about electronic tallies also say that model audit provisions raise public confidence and substantially reduce the chances that DRE and Optical Scan tallies might conceal significant error.
- **Post–election Audit Summit.** Post–election audits are an emerging topic and for good reason. The recent Post–election Audit Summit in Minneapolis attracted eight or nine Secretaries of State offices, dozens of election officials (including Matthew Damschroder from Ohio), many of the most respected computer scientists and statisticians in the country, and dedicated public advocates from many states. The Vice Chair of the federal Elections Assistance Commission, Rosemary Rodriguez, and representatives from the EAC’s Technical Guidelines Development Committee and the GAO also attended. Here’s something remarkable: much comment was made during and after that not only had the summit been extremely informative – even advancing the science of post–election audits – but it had fostered significant new understanding between groups sometimes at odds. It demonstrated that various stakeholders – all sharing the goal that elections be as effective and efficient as possible – can work together far better in the future.

- **Federal legislation** regarding mandatory audits was discussed in 2007 and “opt-in” legislation to provide funding for audit costs is being considered now<sup>6</sup>.
- **New Jersey audit legislation:** On January 15<sup>th</sup>, 2008 the Governor of New Jersey signed into law the nation’s most comprehensive post–election audit law to date. The New Jersey Audit law is based on a statistical approach. In addition, several states are currently considering similar, statistical–based audit laws.
- **Audits can reduce recounts.** Recounts are much less likely if robust audits are being done. Audits add a level of transparency in the process and confidence in the results. Few will want to invest in a recount if the audit is a good one.
- **Minnesota audit experience.** Minnesota conducted its first post–election audit in 2006. Here is a quote from Kevin Corbid, director of elections in Washington County.

"When the post–election audit was passed in Minnesota, I frankly was not a big proponent. Any local election official understands the enormous amount of work that is done by county auditors, county election staff, city and township staff and election judges. The idea of adding more duties was not appealing... I was surprised at how quickly the audit went. I was not surprised by the quality performance of the equipment and our election judges. If this is what is needed to provide some assurance to those who do not have as much confidence in the system then I have no problem continuing to do the audits." <sup>7</sup>

- **Ohio needs a break.** There’s no going back to the days when, “Trust us, we know what we’re doing,” will satisfy Ohioans that elections are as effective and efficient as they should be. “See for yourself,” or even “Bring it on,” will serve Ohio election officials much better in 2008 and beyond. Let’s face it, the public and the media will “bring it on,” in another big hot race anyway. It’s right in many ways, and beneficial to everyone, to waste no more time before putting bullet–proof election practices in place. Without

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<sup>6</sup> See HR 5036, <http://thomas.loc.gov/cgi-bin/bdquery/z?d110:h.r.05036>:

<sup>7</sup> [http://www.ceimn.org/news/minnesota\\_performs\\_first\\_post\\_election\\_review\\_0](http://www.ceimn.org/news/minnesota_performs_first_post_election_review_0)

model audit provisions in Ohio law future elections are more like minefields despite all the hard work election officials do to get them right. Ohio must have outstanding audit procedures if 2008 is going to be approached with real confidence that elections will be businesslike, instead of nightmares.

## Model Post–election Audit Provisions

Model post–election audit provisions can be divided into these components:

1. **Audit method:** Generally, there are three approaches to post–election audits:<sup>8</sup>
  - a. **Fixed percentage model.** Examples are Connecticut (10%), Minnesota (2 – 4 precincts per county roughly 5%) and California (1% audits of all races) which has been in place for 40 years.
  - b. **Tiered model.** The sample size depends on the reported margin of victory. Oregon passed a tiered audit law last summer which is based on HR 811 and S. 2295 (both of which call for 3–5–10% tiered models)
  - c. **Statistical (or Risk Based) model.** Sample size is dynamic; the number of precincts/ballots to count is determined by several factors. The most interesting aspect is that a statistician can give us a "level of confidence" in our audit that increases with larger sample size. Put another way, we don't have to take any larger sample size than necessary to be very confident of the audit. The sample size is surprisingly low for large races (like statewide) where the margin is not very close. That lets us reserve our resources for races that are close. The Statistical model is:
    - i. **More effective** than fixed or tiered audits because it confirms each audited tally to a mathematically–defensible level of confidence that outcome–changing error was not overlooked.

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<sup>8</sup> A different approach to ensure the accuracy of voting systems is **Universal Ballot Sampling (UBS)**. Ballots are counted at the precinct immediately after the polls close. UBS has many advantages and is worth serious consideration in the future. It was not recommended because of concerns about staffing Ohio's 11,000 precincts, increasing usage of absentee ballots that would not be included, and legal and practical difficulties when dealing with sealed paper audit trail canisters. Reference: <http://www.electiondefensealliance.org/upspr>

- ii. **More efficient** than fixed or tiered because resources are more concentrated where needed and not wasted where they are not. Most statewide races require very small paper ballot counts to confirm machine tallies (less than 3 percent). Resources are saved for the very few close races that require higher paper ballot counts to validate the official count at the desired confidence level. With fixed or tiered methods, most races are audited by hand counting many more ballots than necessary, while the few close races are not audited enough.

**Confidence levels** play an important role in the discussion of audit methods and are often misunderstood. A **confidence level** describes a particular statistical test, not generalized confidence in election processes. It applies to a specific claim or hypothesis. In this case, the hypothesis is that

**the outcome is correct – a 100% hand recount would not change who won**

An effective post-election audit can support this claim with high statistical confidence, i.e., a very low probability of being wrong. The basic strategy of a statistical audit is to determine the minimum number of precincts (or audit units) that would have to be miscounted if the outcome were *not* correct, and then to choose an audit sample size that has

**a known high probability of detecting at least one of these miscounted precincts.**

This means that if there is one significant discrepancy, additional precincts should be audited to determine if there is enough to change the results of the election.

The confidence level used in this paper depends on an important assumption

**There is no miscount above a specified percentage level (we used 20%) in any one precinct.**

Because of this assumption, the Audit Team should

- look for unexpected results before starting to perform the audit
- allow precinct challenges as described

## 2. Sample selection method (for all of the models)

- a. Establish the number of races to be audited. E.g. Federal, top State, some other races. This is decided in bill-drafting and typically might include 10–12 races statewide and may or may not include additional local races.
- b. Units – e.g. precinct, machines, or batches depending on statute – must be randomly selected after the results have been tabulated and recorded. This selection should be done in public and immediately before the audit starts.
- c. “Batching” absentee, early voting, provisional, and overseas ballots into “units” or ballot batches provides important benefits
  - i. Privacy is preserved for absentee, provisional, and overseas ballots. Precinct or machine based samples can unacceptably expose ballot identity. (This is a particular issue for small jurisdictions or precincts.)
  - ii. Complexity is considerably reduced for absentee, provisional, and overseas ballots when batched because officials do not have to search through ballots to find specific precincts or machines for auditing. (This is a particular issue for large jurisdictions.)
- d. Random selections of the units (precincts) to count:
  - i. A random sample is absolutely critical to obtaining the desired confidence level. Although some people may suspect problems in certain areas and want to choose them for the audit, such non-random selection cannot be the basis of the official audit. Those areas can be audited also (see “Precinct Challenges”, below), but only in addition to the randomly selected units (2b above) of the official audit.
  - ii. Ways to select the units (precincts) include putting all the precinct names on pieces of paper, folding them, and then drawing the required number blindly from a hat or bowl. Other options will be described later for large counties.

It may seem possible to use a computer program of some type to choose the units, but this option is not to be used. Independent sample selection

is essential to post-election audits because one primary goal is to check for error in machines using software. Introducing more software in the audit procedure undermines this purpose, and makes it less than transparent to observers.

### 3. Counting process

- a. Three or four person teams seem to work best
- b. “Blind counting” is essential, meaning counting personnel do not know the machine tallies that their counts will eventually be compared to.
- c. Other best practices can easily be developed in bill-drafting, rulemaking, and specific practices adopted by counties and subject to public comment.

### 4. Triggers and escalation

- a. The effectiveness of an audit crucially depends upon appropriate, proportionate responses to the result of auditing the initial sample. If the miscount rate observed in the initial sample leaves some reasonable doubt about the outcome of the election, additional sampling is appropriate in order to resolve the doubts. Unexpectedly high miscount rates may merit further random sampling, and/or other forms of investigation, in order to understand their causes and how they can be prevented in the future. However, some possible responses – for instance, mandatory 100% recounts if any discrepancy whatsoever is found – are (generally) disproportionate and even dangerous, since they create perverse incentives to subvert the audit.
- b. “Triggers” define conditions under which an “escalation” or expansion of the audit is *mandatory*, based on observed discrepancies between manual counts and machine counts. For instance, a one tenth of one percent (0.1%) change in a candidate’s vote share, within the ballots subject to audit, might trigger “escalation” (as further defined below). Mandatory triggers can promote public confidence in the audit process because they do not depend upon the discretionary judgments of an audit team. The 0.1% trigger described above is viable in many cases because, although audits may reveal small discrepancies in several precincts, these discrepancies often balance or cancel. Therefore, this trigger will “fire” relatively infrequently in circumstances that warrant further

scrutiny. The initial sample size can be set such that in almost all cases, the outcome is confirmed (to the pre-determined confidence level) *unless* this trigger fires. (Note that a 0.1% discrepancy does not necessarily, on its own, bring an election outcome into doubt.)

- c. "Escalation" refers to additional counts based on the results of the initial audits. Typically, a mandatory escalation based on a trigger would require a second number of randomly selected units equal to the first number of units counted. For instance, if the initial sample comprised 5 precincts or units, the mandatory escalation would comprise an additional 5 precincts or units. Audit Teams should always have discretion to escalate audits if the initial results leave doubt about the correct outcome. (Again, discretionary escalation should be unusual.)
  - d. It is not difficult to clearly define all triggers and escalation in less than a page of statutory language.
5. **Precinct challenges:** Allowing candidates, election officials or independent auditors to add some precincts of high interest (in addition to the random sample) will further bolster confidence for all stakeholders. This also allows a more efficient application of random sampling since obvious discrepancies can be investigated without depending purely on the random selection process. The random process can therefore be geared toward finding less obvious but more numerous discrepancies, which actually saves resources.
6. **Transparency** is essential throughout all auditing procedures. Clear public access, which does not interfere with the conduct of the audits, should be codified appropriately in both statute and rule. A primary goal of conducting audits is to increase public confidence in the results. It would be counter-productive not to plan for high standards of transparency at each step so the public can see for themselves how all aspects are conducted.

Allowing observers into the counting room is not sufficient if they can't all see what is happening. They must be able to see the ballots (whether optical scan or paper audit trail) and voter selection. Transparency can be helped greatly if the process is captured

by a video camera and projected to monitors. The whole event can be preserved on tape or DVD.

- 7. Costs:** Model audit provisions require little more resources than inferior provisions – sometimes less. Our goal, in presenting different audit models, is to offer an option that requires the least hand counting while assuring everyone that the process was accurate.

## Recommendations

The following recommendations should be considered when working on audit legislation, directive, or implementation plans. We plan to provide additional recommendations related to more challenging areas (i.e., selecting precincts, how many votes to count, specific escalation triggers, cost estimates).

### Legislation

- **Audit must be independent.** If the audit is controlled by one or another political entity, or only election officials, the outcome will often not be accepted. There are several ways to get an independent audit and further work on this may be appropriate. Briefly, an independent audit authority (management team) at the state level, separate from and not employed by elections officials, can be established to manage, provide oversight, and report, while regular employees at the local levels do the physical audit. A common best business practice to be considered is to hire a professional auditing firm to be core part of the independent audit authority, and possibly at local levels to help do the physical audits.
  
- **Audit should be non-partisan or bi-partisan.** The selection process for the Audit Manager and Audit Team, as well as decisions made during the audit, must be free from partisan influence, as well as the influence of any elections officials who in essence are experiencing their own work being checked, and who at times could experience an additional quantity of work depending on certain findings of the audit. A non-partisan team is preferable, and we think it is possible. Otherwise, a bi-partisan team with adversaries in balance is necessary, but in this case, the team manager must be non-partisan.
  
- **Audit Team.** The Audit Team should
  - be selected by Audit Manager(s)
  - include at least one member with audit experience and one member with some statistical experience to provide guidance on the audit method (e.g., confidence level)
  - start at least one month before election to insure proper planning so audit starts promptly, is run effectively, and finishes in time for certification.
  - serve until results are finalized and election is certified.

- include no more than two members of the same political party
  - include at least one person with no political party affiliation (other than voting in elections that are not Primary elections)
  - vote on important issues that cannot be resolved and document these issues and decisions
  - bring unresolved issues (including tie votes) to the Audit Manager for resolution.
  - be subject to conflict of interest limitations. Recent New Jersey legislation includes specifications for Audit Team members and does not allow anyone who is
    - on committee of any candidate for political office in the elections that are subject to the manual audit
    - an employee of, or reports to, the Audit Manager
    - serving as an officer or an employee of any entity that designs, manufactures, or services a voting system used in the State.
- **Selecting contests (candidate or issue) to audit.** The following contests should be audited. The margins are included to avoid auditing races with wide margins or no opposition. They were chosen by looking at the 2004 and 2006 Ohio Election results with the goal of including a reasonable number of contests.

#### Statewide contests

- President, US Senator, Governor
- Other statewide offices with margin under 20%
- Statewide Issues with margin under 20%

#### Non-statewide contests

- US House races with margin under 40%
- State Legislative races with margin under 40%

There was some concern that setting margins for audits could set a target for fraud to push the margin over a threshold to avoid an audit. It might be a good idea to randomly select some of the contests that have margins above these levels.

- **Audit method.** We recommend a Statistical method for selecting the number of precincts to be audited, although we do present an alternative for a Tiered method. While the Statistical method is usually more efficient and effective, the simplicity of the

Tiered method would make for easier implementation as well as acceptance by the public. The Fixed method should not be used since it is least effective and more costly.

**Statistical method.** In the Statistical method, the audit team would determine the sampling size based upon scientifically reasonable assumptions, with respect to each audited election.

We recommend Aslam/Popa/Rivest's "PPEBWR" sampling method (which is referred to here as the APR method).<sup>9</sup> This method includes two important features

- Statistical analysis is done to determine the number of precincts needed based on the number of votes cast and the margin of victory.
- Precincts with higher vote counts are proportionally more likely to be selected than precincts with lower vote counts. This makes sense since larger mistakes are possible. This is particularly helpful in Ohio which sometimes large variations in precinct sizes. The APR paper referenced earlier includes an example of Ohio Congressional District #5 which in the November 2004 election had precinct vote totals ranging from 132 to 1,637.

With the APR method, we recommend the following

- 99% confidence level for statewide races and federal races
- 90% confidence level for Ohio legislative races. The lower level of confidence is recommended because of cost considerations. State legislative races have fewer votes cast and achieving a 99% confidence level could be very costly if there are many close races.
- At least 1% of votes cast be audited for all contests selected to be audited. This ensures that a minimum audit is done in all cases.
- If there are less than 100 precincts the audit should include at least 2 precincts.

The APR method will allow Ohio to perform high quality audits at the minimum cost. A brief comparison of effectiveness and cost is provided after a description of the Tiered method and additional details are provided at the end of the paper.

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<sup>9</sup> <http://people.csail.mit.edu/rivest/AslamPopaRivest-OnAuditingElectionsWhenPrecinctsHaveDifferentSizes.pdf>

**Tiered method.** The most widely known Tiered method is the one proposed in HR 811<sup>10</sup> in 2007. HR 811 included the following tiers. Note: if the recommendation on contests to audit is selected, contests with margins above a certain level would be excluded from the audit.

Tier	Margin of Victory	Percentage of Votes to Count
1	Below 1%	10%
2	From 1-2%	5%
3	Above 2%	3%

If a Tiered method is preferred, we recommend separate tiers for statewide and non-statewide contests. This is because non-statewide races have far fewer precincts and need a higher percentage of precincts audited to achieve a reasonable confidence level. Our recommendation for a Tiered method is included in the table below.

Type	Tier	Margin of Victory	Percentage of Votes to Count
Statewide	1	Below 2%	15%
Statewide	2	From 2-10%	5%
Statewide	3	Above 10%	3%
Non-Statewide	1	Below 5%	20%
Non-Statewide	2	From 5-20%	10%
Non-Statewide	3	Above 20%	5%

- **Comparing statistical and tiered methods.** As mentioned earlier, the main advantage of a statistical method is that it is more efficient. It counts only as many precincts (votes) as it needs to achieve the desired confidence level. Tiered and Fixed methods are more likely to count too few votes in close races and too many votes when races are not close.

The APR method has the additional advantage of taking precinct size into account during its selection process by giving a proportionally higher priority to large precincts.

<sup>10</sup> <http://thomas.loc.gov/cgi-bin/bdquery/z?d110:h.r.00811:>

Since miscounts can be higher in larger precincts, this results in needing to count fewer votes to reach a desired confidence level

The following table includes the number of votes audited (which is based on the number of precincts selected) and resulting confidence levels (CL) for some races where a Tiered method counts more votes than necessary.

Contest	Margin	APR		HR 811		Suggested Tiered	
		Votes	CL	Votes	CL	Votes	CL
President	2.1%	89,776	99.9%	171,669	100%	286,114	100%
Supreme Court Justice 1	6.4%	89,776	99%	171,669	100%	286,114	100%
US House District 1	19.7%	3,817	99%	9,288	100%	9,288	100%

**Notes**

- In the Presidential race, you can see that both Tiered methods count far more votes than necessary. The APR 99% method actually only needs to count 50,016 votes statistically, but the 1% minimum rule increases the audit level to 89,776 votes and provide a 99.9% level of confidence.
- In the Supreme Court races, the vote counts are the same as the Presidential race although the margin was larger. For APR, the calculated vote count needed was 20,183, but the 1% minimum was triggered again. For the Tiered methods, the same Tier was used and so once again there is significant over-counting by those two methods.
- For US House District 1, the vote totals are lower because this is not a statewide contest, but even here the Tiered methods count too many votes.

Just as importantly, here are some examples from the 2004 election where a Tiered method counts too few precincts. This shows up mainly in the non-statewide contests.

Contest	Margin	APR		HR 811		Suggested Tiered	
		Votes	CL	Votes	CL	Votes	CL
Ohio Senate District 20	7.4%	5,990 11,739	90% 99%	5,078	70%	16,926	98%
Ohio House District 1	1.0%	31,338 42,701	90% 99%	2,518	20%	10,072	36%
All races below 10%	<10%	323,160	90%	114,301	28% avg	273,474	65% avg

**Notes**

- In the Ohio Senate District 20 race, you can see the significant difference between vote counts for APR 90% and APR 99%. In non-statewide races, achieving the higher level of confidence can be expensive. The HR 811 Tier counts fewer votes, but at a much lower level of confidence. The Suggested Tiered method is the most effective, but requires a large number of votes to be counted.
  - The Ohio Senate District 20 race also shows the cost effectiveness of the APR method. Because it takes precinct size into account, it is able to achieve a 99% level of confidence auditing 11,739 votes while the Suggested Tiered method counts more votes (16,926), but only reaches a 98% confidence level.
  - For Ohio House District 1, the margin is very small and APR requires many votes to achieve a high level of confidence. The Tier methods count fewer votes, but achieve a very low level of confidence.
  - The last row totals all 2004 races with margins less than 10%. This shows where the HR 811 Tiered method drops to a very low confidence level when it is most important (in close races) to have a high level of confidence. The Suggested Tiered method does better, but at a much higher level of votes. The APR method counts the most votes, but achieves the highest level of confidence.
- **Selecting precincts to audit.** Precincts should be used as the basis for the audit because reporting results by precincts is currently done in all counties.

**Statistical method.** If the Statistical method is used, the first step is to choose a confidence level. For example, setting the confidence level at 99% means that only one time in a hundred would a result-changing error go undetected.

Once the number of precincts is determined for a race, the Audit Team determines how the precincts are selected. With the APR sampling method, an algorithm is used which chooses precincts based on their size (larger precincts are more likely to be chosen).

**Tiered method.** If the Tiered method is used, the number of precincts is determined by the levels in the Tier (described earlier).

#### Statewide races

- Precincts are selected in each county according to the percentage determined by the Audit method (i.e., precincts are not selected statewide).

#### Non-statewide races

- Precincts are selected from all precincts that voted for the chosen race according to the percentage determined by the Audit method (i.e., precincts are not selected statewide).

#### All races

- Precincts are selected randomly (all precincts have an equal chance of being selected)
- Precinct selection is done manually (i.e., computers are not used) to avoid creating any doubt about the randomness and having to audit the selection program on the computer.
- Precinct selection is done immediately before the audit starts.
- Unofficial results are not made available to the people doing the counting.

**Precinct challenges.** These are **in addition** to precincts selected above. These challenges apply to all contests.

- Losing candidates (or issue supporters) can make precinct challenges up to a reasonable limit. The suggested limit is five additional precincts for statewide races and two for non-statewide races. They can request precincts beyond this limit, but must provide a justification for each precinct. The Audit Team decides if the additional auditing is justified.

- Any Ohio registered elector can make precinct challenges with the Audit Team deciding if the additional auditing is justified.
  - Audit Team members can make any number of precinct challenges.
  - Precinct challenges are allowed for all contests (including those not being audited because of a large margin of victory). This allows for investigation of possible miscounts that prevented the contest from being audited. If the precinct challenge audit finds a significant miscount, the contest should be included in overall audit.
- **Random must be random.** Random selection of units (e.g., precincts, machines, or Optical Scan batches) means each audit unit has an equal chance of being selected.

If the APR sampling method is used where precinct size is taken into account, the selection is still made in a drawing or with dice although the larger precincts are still more likely to be chosen. Other than precinct challenges, specific precincts should never be selected by the Audit Team or BOE staff.

- **Who performs the audit.**
  - Most audits should be performed by BOE staffs with public observation.
  - An independent auditing firm should be used for 2–3 (randomly selected) counties after a Presidential election so some professional auditing is done
- **Transparency.** Public observation is crucial to the audits being trusted. Observers must be able to be close enough to confirm the proceedings without interfering with the process. Results for all counties, precincts, races, etc must be released when the final results are announced.
- **Auditing Election Day votes and chain of custody**
  - All election day votes for selected races/issues in a selected precinct are counted manually. Hand counting is essential to post–election audits, and is required in the following seventeen states' post–election audit provisions: AK, AZ, CA, CO, CT, FL, HI, IL, MN, MO, NM, NJ, NY, NC, OR, WA, WV.<sup>11,12</sup>

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<sup>11</sup> Electionline.org Briefing: Case Study: Auditing the Vote (March 2007) - <http://www.pewcenteronthestates.org/uploadedFiles/EB17.pdf>

- DRE votes are counted by hand from the VVPAT
  - If a VVPAT is readable and complete (had zero results and end of election), but not signed, it can be used. The lack of proper signature(s) is noted but is not cause for exclusion.
  - If a VVPAT is compromised (missing zero report, votes, or end of election), the VVPAT should be reprinted or the votes on the DRE memory are used. The problem is noted for the final report.
  - OS ballots are counted by hand.
  - Precinct vote counts are compared with the unofficial count.
  - Precinct poll book signatures are recounted and compared to the manual vote count.
- **Auditing non-Election Day votes and chain of custody (absentee, overseas, provisional)**
    - All early/absentee and military ballots in a selected precinct are counted by hand and compared to the official count.
    - Provisional ballots submitted to a selected precinct are recounted by hand and compared to the official count.
    - Provisional ballots submitted to a selected precinct are checked to verify that the decision to accept or reject decision was correct. The number of incorrect acceptances and rejections is reported along with the number of rejections for each reason (e.g., wrong precinct, not registered). It would also be helpful to determine how many of the “wrong precinct” rejections occurred when the voter was at the correct polling place, but ended up at the wrong precinct so improvements can be made in the future.
    - Precinct vote counts are compared with the final unofficial count.
  - **Procedural and chain of custody audits** are critical because an audit assumes that procedures have been followed and all ballots are available. For example, if Optical Scan ballots or the paper audit trail from a DRE is unavailable, the audit of a particular precinct cannot be done. Voting System vendors often stress the need for these layers of security.

Chain of custody audits should include verifying security procedures were followed

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<sup>12</sup>Audit Survey by National Association of Secretaries of State:  
[http://nass.org/index.php?option=com\\_docman&task=doc\\_download&gid=54](http://nass.org/index.php?option=com_docman&task=doc_download&gid=54)

- Memory cards on voting machines initialization through L&A testing, Election Day, transmission to BOE and storage.
- Paper or Optical Scan ballots from Election Day through transmission to BOE and storage.
- Records of the numbers of ballots used, not used, and destroyed.
- Tabulation Equipment
- Records of receipts for all transfers of memory cards or ballot boxes.
- Ballot boxes (possibly used for 15 days)

Procedural audits should include verifying

- the use of security procedures
  - the use of chain of custody procedures
  - reconciliation of signature books
  - no problems in audit logs from tabulators and scanners
- **Triggers and escalation.** If the Audit Manager(s), or at least two members of the audit team, determine that an audit indicates a substantial possibility that a complete manual count would alter the outcome of any contest, the Audit Manager shall direct manual counts of as many additional precincts as the audit team recommends.

Additional audits shall be conducted in any county if the initial audit finds a one tenth of one percent (0.1%) change in a candidate's vote share, within the ballots subject to audit. The number of precincts added to the audit shall be the same as the original number selected and should be chosen by the same process.

The Audit Team should determine if all contests should be included in the additional audit based on whether the problem appears to be a general problem rather than being specific to the individual contest. After this recount, the need for additional precincts or a full recount should be re-assessed.

- **Audit occurs before certification.** The audit results should be announced and vote counts corrected before election results are certified. This important requirement may necessitate changes in the current election timeline.

We recommend the following changes for post-election audits

- The post-election audit should begin after the official canvass has been completed<sup>13</sup>. This ensures that the audit results are compared with final results from the BOE.
- The overall results of the official canvass should be announced when available so that losing candidates and interested Ohio electors can study the results and decide if they want to request any Challenge Precincts. These results must not be available to workers counting the votes while audits are being performed.
- The number of days allowed for the audit, between official count completion and boards' certification should be included in the timeline.
- The time allowed for requesting a recount should start after the certification of results, which is to include audit completion.
- The Secretary of State should not declare the results until after the audited results that are certified.

### Preparation

- **Pilots.** We recommend pilot audit processes (not official audits) be conducted under realistic conditions before the Presidential Preference election. Two each from small, medium, and large jurisdictions – or six in all – could pilot a model audit of the results from the March primary. It would make sense to include the counties (e.g., Cuyahoga, Van Wert) that switched voting systems in March to help them identify problems associated with their first use of a new system. Some could use the Tiered method and others the Statistical (APR) method to evaluate cost and effectiveness. Officials from neighboring jurisdictions could assist so that what is learned is more widely disbursed. The greatest benefit will arise from the added participation of the Secretary of State's office. Preparation needs, logistics, transparency, methodology, and resource requirements are all sure to be well-instructed by such pilots – while there is still sufficient time to tweak bill language, rulemaking, and plans for training and implementation.

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<sup>13</sup> From our reading of RC 3513.22, the boards canvass and “promptly certify”. The law may need to change here in order to do audits post-canvass and pre-certification.

- **Help is available.** Volunteers and groups with audit expertise are available to help. These groups can also help support Ohio's conduct of post-election audits if adequate procedures are setup and followed. They can also help educate the public and media that small discrepancies are inevitable in large elections, are corrected by an audit, and therefore should not be exaggerated.

## Cost Estimates

We have done some cost estimates based on the 2004 and 2006 elections assuming the recommended audit provisions were in place at the time. The columns in the following tables are

- **Office:** Federal or statewide office.
- **No of Races:** the number of races for the office
- **Avg Margin:** average margin of victory
- **CL Min:** Minimum confidence level for the method for this office
- **Audits Below 50% CL:** number of audits with a confidence level below 50%
- **Avg CL, Close Races:** average confidence level for races with margin less than 10%
- **Ballots to Audit:** number of votes to count in the audit (which is based on the precincts selected).
- **Cost:** cost of the audit (the number of ballots to audit multiplied by \$.21 /vote)

## 2004 Election Estimate

Office	OH 2004			APR					HR 811				
	No of Races	Avg Margin	Races To Audit	CL Min	Audits Below 50% CL	Avg CL, Close Races	Ballots to Audit	Cost	CL Min	Audits Below 50% CL	Avg CL, Close Races	Ballots to Audit	Cost
President	1	2%	1	99%	0	99%	89,776	\$18,638	100%	0	100%	171,669	\$35,639
US Senate	1	28%	1	99%	0	99%	89,776	\$18,638	100%	0	NA	171,669	\$35,639
Governor	0	NA	0	NA	0	NA			NA	NA	NA		
Other Statewide	5	33%	2	90%	0	90%	179,552	\$37,275	100%	0	100%	343,338	\$71,278
US House	18	39%	14	99%	0	99%	75,900	\$15,757	100%	0	NA	133,822	\$27,782
OH Senate	16	39%	13	90%	0	90%	38,227	\$7,936	70%	0	70%	69,827	\$14,496
OH House	99	44%	58	90%	0	90%	323,160	\$67,089	10%	15	28%	114,301	\$23,729
<b>Total</b>	<b>140</b>		<b>89</b>				<b>796,391</b>	<b>\$165,333</b>				<b>1,004,626</b>	<b>\$208,563</b>

## 2004 Cost Notes

- The APR method counts fewer votes for the statewide races and still has a very high confidence level.
- The HR 811 method counts fewer votes in the non-statewide races and sometimes produces very low confidence levels (e.g., 10% in one Ohio House race).
- In 15 of the 58 Ohio House races audited, the confidence level was below 50%.
- In the close Ohio House races (margin below 10%), the average confidence level was only 28%.
- The Tiered method suggested above (not shown below) provides higher confidence levels than HR 811 (average confidence level of 65% in the close Ohio House races, but at a higher cost (\$317,400 instead of \$208,600).

## 2006 Election Estimate

Office	OH 2006			APR					HR 811				
	No of Races	Avg Margin	Races To Audit	CL Min	Audits Below 50% CL	Avg CL, Close Races	Ballots to Audit	Cost	CL Min	Audits Below 50% CL	Avg CL, Close Races	Ballots to Audit	Cost
President	0	NA	0	NA	0	NA			NA	NA	NA		
US Senate	1	12%	1	99%	0	99%	66,588	\$13,824	100%	0	NA	125,567	\$26,068
Governor	1	24%	1	99%	0	99%	66,588	\$13,824	100%	0	NA	125,567	\$26,068
Other Statewide	10	13%	9	90%	0	90%	599,292	\$124,414	99%	0	100%	1,213,814	\$251,991
US House	18	24%	15	99%	0	99%	181,855	\$37,754	19%	1	47%	127,872	\$26,547
OH Senate	17	38%	10	90%	0	90%	40,200	\$8,346	48%	1	51%	40,410	\$8,389
OH House	99	34%	68	90%	0	90%	299,249	\$62,125	8%	22	24%	96,314	\$19,995
<b>Total</b>	<b>146</b>		<b>104</b>				<b>1,253,772</b>	<b>\$260,286</b>				<b>1,729,544</b>	<b>\$359,057</b>

## 2006 Cost Notes

- The APR efficiency on statewide races helps more in non-Presidential elections when Ohio statewide offices are contested.
- In 22 of the 68 Ohio House races audited, the confidence level was below 50%.
- In the close Ohio House races (margin below 10%), the average confidence level was only 24%.
- The Tiered method suggested above (not shown below) provides higher confidence levels than HR 811 (average confidence level of 66% in the close Ohio House races, but at a higher cost (\$584,700 instead of \$359,000).

## Cost Estimate Notes

Cost estimates are based on an estimated cost to manually count each vote. We have used an estimated cost of \$0.21 to audit each vote based on the following:

- The first audit done in Minnesota (after the November 2006 election) cost an estimated \$0.09 to \$0.10/per hand counted vote to count 277,177 votes. Here is an excerpt from the Audit Report<sup>14</sup> prepared by the Citizens for Election Integrity Minnesota:

<sup>14</sup> <http://ceimn.org/files/CEIMNAuditReport.pdf>

"In an informal survey of election officials the estimated cost of the election judges' wages to count votes ranged from \$80 to \$500 per county. This variation is due to the different hourly wages paid to election judges as well as differing numbers of precincts that were audited in each county and variation in the size of the precincts audited. Hennepin County, (largest county in the state with 426 precincts) audited eight precincts in five cities. The estimated cost for election judges in Hennepin County was \$900. Based on this informal survey the projected total statewide cost for election judges is between \$24,500 and \$27,000."

- Arizona's Pima County carried out their first mandatory random manual audit since passage of their State's audit law and examined four contests each on polling place ballots from nine precincts, plus additional provisional ballots, for a little over \$0.13/ballot.<sup>15</sup>
- For Ohio, we used an estimate of \$0.15/vote for Optical Scan vote and \$0.25/vote for DRE votes. We used slightly higher costs to be conservative and remembering that there may be extra administrative costs. For audits in DRE counties, we increased the estimate on the assumption that dealing with paper audit trails will be more difficult and thus more expensive.
- We determined an overall cost of \$0.21/vote based on an estimate that about 58% of votes in 2008 will be cast on DRE's. This estimate is based on the votes cast in each county in 2004 and assuming that Cuyahoga and Van Wert will be Optical Scan counties in 2008.
- The data used for the margins and votes cast were taken from the Ohio Secretary of State's web site.<sup>16</sup>
- Considerable effort was involved in calculating the ballot counts and costs, but the work was done in a short period of time and should be independently verified.<sup>17</sup>

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<sup>15</sup> [http://www.verifiedvotingfoundation.org/downloads/PamelaSmithTestimonyFinal\\_2007mar20.pdf](http://www.verifiedvotingfoundation.org/downloads/PamelaSmithTestimonyFinal_2007mar20.pdf) which has other useful information on costs and audits in general.

<sup>16</sup> <http://www.sos.state.oh.us/sos/ElectionsVoter/electionResults.aspx>

<sup>17</sup> The spreadsheet used for the calculations can be found here:

[http://www.caseohio.org/PageDetails/Audits/OH\\_Audit\\_Cost\\_Estimate\\_2004\\_2006.xls](http://www.caseohio.org/PageDetails/Audits/OH_Audit_Cost_Estimate_2004_2006.xls)

## Audits in 2008

We realize it is not practical to perform a full set of post-election audits after the November, 2008 elections because legislation, directives, and BOE procedures all need to be completed. It also makes sense to start small with a new process.

If HR 5036<sup>18</sup> should become law, the documented reasonable costs of the proposed 2008 audit would be eligible for reimbursement by federal funds.

We do feel strongly that our limited audits can be done in 2008 by making the following alterations to the recommendations above.

- **Audit Manager:** Attorney General & State Auditor
- **Audit Team:** Two members with audit and statistical experience.
- **Selecting contests (candidate or issue) to audit:**
  - Statewide contests
    - President
    - Statewide Issues with margin under 2%
  - Non-statewide contests
    - US House races with a margin of 10% or less (there were only 3 races under 10% in 2006 and none in 2004).
    - State Legislative races with margin under 10%
- **Audit method:** APR method as described above, but with 99% confidence level for all races.
- **Precinct challenges:** as described above
- **Counting Election Day votes:** as described above

To provide a rough idea of the effort involved for 2008, the below are the contests that would have been audited if these rules had been in place in 2004. Higher voter turnout and closer races would increase the costs.

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<sup>18</sup> [http://holt.house.gov/HR\\_5036.shtml](http://holt.house.gov/HR_5036.shtml)

Contest	Votes To Count	Estimated Cost
President	89,776	\$18,638
Issues	None	None
US House	None	None
OH Senate	11,739	\$2,437
OH House	333,529	\$69,241

## Further Study

Some topics not covered in this paper that could be addressed in the future include investigating

- a transparent method for the Audit Team to select precincts using the APR method.
- a lookup table to quickly determine the number of precincts to be audited for a contest when the APR method is being used (the authors of the APR method are working on this).
- when precinct samples can be shared for multiple contests to reduce effort and cost.
- when to continue auditing a contest when discrepancies have been found including 1) recalculating the APR confidence level<sup>19</sup> and 2) handling discrepancies from DRE more stringently than Optical Scan since DRE's should match exactly.
- ORC changes necessary to allow post-election audits.
- how absentee and provisional ballots are handled in different counties and how they should be audited
- a "Pilot Plan" where we look at the several things to consider: different audit approaches (Tiered etc.); different audit processes (number on teams, setup to read DRE, use of video etc).
- whether chain of custody audits are best done separately from the vote count audit

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<sup>19</sup> <http://statistics.berkeley.edu/~stark/Preprints/ppebwrwd08.pdf>

## Conclusion

- Passing legislation and conducting a model post–election audit in 2008 benefits all stakeholders.
- It's manageable, politically viable and the cost is reasonable.
- It's necessary for 2008 to ensure that miscounts are corrected before certification.
- It will raise public confidence in Ohio elections.

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\*\* 2007 Post–election Audit Summit Sponsor Host Committee

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<sup>20</sup> <http://www.electionaudits.org/node/1>